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DEVELOPMENT APPROVAL

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Queensland Government

Concept Stormwater Management Plan Report

ROL1 – Riverside, Jimboomba

PREPARED FOR CELESTINO PTY LTD

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Executive Summary

Calibre Professional Services Pty Ltd has been commissioned by Celestino Pty Ltd to prepare a Concept Stormwater Management Plan in support of the initial Reconfiguring of Lot (ROL) application for Stage 1 of the Riverside development in Jimboomba. This report demonstrates that the stormwater and flood management strategies adopted for ROL Stage 1 development, are generally in accordance with the master planning strategies and comply with the Queensland Government's Department of Infrastructure Local Government and Planning (DILGP) guidelines, State Planning Policy (2017), Logan City Council's Planning Scheme (2015) and all relevant best practice guidelines and standards.

> *The previous report (Issue B) was prepared to demonstrate that the stormwater and flood management strategies adopted for ROL Stage 1 development were in accordance with the master planning strategies and in general compliance with the relevant State and Local guidelines. Since the time of the Issue B submission the Queensland Governments Department of State Development, Manufacturing, Infrastructure and Planning have responded with Further Issues for PDA Development Application (Ref: DEV2017/901, dated 19/02/18). This issue (C) of the report has been prepared to address the stormwater related items of the Further Issues document and document minor layout amendments.*

The outcomes of this report are as follows:

- *Stormwater Management (Quantity)* – Hydrological analysis using XP-RAFTS has determined the change in peak flows at each discharge location from the site as a result of the ROL Stage 1 development. The peak flow management strategy (summarised on **Figure 3.1**) incorporates a catchment diversion and partial construction of the detention basin on the future School Site. For discharges to the north of Teviot Road, XP-RAFTS analysis demonstrates a 1% to 3% reduction in peak flows. For discharges to the west-east drainage path, previous (master plan) analysis demonstrates no adverse impact over the Logan River. For north east discharges to State Land on Lot 71 SL8963, analysis indicates up to a 5% reduction in peak flows. For south east discharges to the State Land on Lot 71 SL8963 a slight increase in peak flows (up to 192L/s) has been determined, however this equates to only a 10mm difference in 1% AEP flood levels and 0.1m/s increase in velocities (with a maximum velocity lower than 1m/s), which is not considered to be perceivable, let alone adverse. Overall stormwater quantity management investigations demonstrate no adverse impact at each discharge location. Refer to **Section 3** of this report.
- *Waterway Stability Management* – Hydrological analysis presented in **Section 3** demonstrates no adverse impact for the 63% AEP storm for discharges to the north of Teviot Road and to Lot 71 (for south east and north east discharges). Additional hydrological analysis using XP-RAFTS was undertaken to assess the change in peak flows along the west-east drainage path (south of ROL Stage 1). Results indicate a reduction in peak flows (by 1% to 5%) downstream of ROL Stage 1 within the west-east drainage path. The online waterway stability detention basin proposed in the master plan analysis is not required for the interim ROL Stage 1 development. Refer to **Section 4** of this report for further details.

  > *Minor amendments were made to the Waterway Stability Management investigation as part of the Issue C updates. The basis of the modelling such as configurations, objectives and outcomes remain consistent with the previous Issue of this report.*

- *Local Flooding* – As a portion of the main west-east drainage path running through the master plan area will be constructed in ROL Stage 1. Refined XP-RAFTS and HEC-RAS modelling was undertaken to provide an adequate channel design under interim ROL Stage 1 and fully developed master plan conditions. Appropriate flood immunity levels were determined in the local flooding investigations. Refer to **Section 5** of this report.
- *Stormwater Management (Quality) & Total Water Cycle Management* – A stormwater quality management and total water cycle management strategy utilising bioretention basins, rainwater harvesting, wetlands, water features and vegetated swales was proposed as part of the master plan investigations. Since the master plan analysis, the proposed semi offline wetland for Catchment U has been removed from the strategy.

  > *Since the Issue B report, further modelling of the proposed bioretention basin surface areas (incorporating extended detention depth, batters and freeboard requirements) has been undertaken. The updated modelling demonstrates the Precinct A SQIDs achieve the relevant WQO's as required under the SPP (2017). Further details of the ROL 1 Stage 1 stormwater quality mitigation results have been provided.*

- Living waterways is an innovative approach which integrates stormwater features into environmental, educational, community and economic benefits. For the Living waterways analysis, the master plan was divided into three Stormwater Quality Precincts (SWQ Precinct A, B and C). Using the framework a drop rating of 1 has been demonstrated for the first SWQ Precinct A (which incorporates ROL Stage 1). Based on this, the performance outcomes of the SPP (2017), required under DILGP guidelines, will be achieved and the proposed stormwater management strategy is considered to be appropriate. Details for the treatment measures required during ROL Stage 1 have been provided. Refer to **Section 6** of this report.
- *Construction, Operational Management & Maintenance of SQIDs* – Details for construction, operational management and maintenance of stormwater quality improvement devices (SQIDs) is detailed in **Section 7**.

Based on the above outcomes, it is recommended that the proposed stormwater strategies for ROL Stage 1 development be approved and adopted in detailed design. Future design may result in changes to the concepts, however the design objectives are to be maintained.

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1 Introduction

Calibre Professional Services Pty Ltd (Calibre) has been commissioned by Celestino Pty Ltd to prepare a Concept Stormwater Management Plan in support of the initial Reconfiguring of Lot (ROL) application for Stage 1 of the Riverside development in Jimboomba. Stage 1 forms part of a larger master plan development within the Greater Flagstone Priority Development Area (PDA). For clarity and consistency, Stage 1 development will here in be referred to as 'ROL Stage 1' and the overall master plan development will be referred to as the 'master plan' area. Catchments indicated in this report, refer to runoff catchments or the area from which runoff flows to the downstream location.

Calibre has previously submitted a Concept Stormwater Management Plan Report (Concept SWMP, No. **B13343.W-02A** dated November 2016) and a Flood Investigation Report (No. **B13343.W-01B** dated November 2016) for Preliminary (Masterplan) Approval for the overall Riverside development (incorporating Stage 1). Following assessment of these initial reports, Economic Development Queensland (EDQ) issued requests for further information regarding stormwater quality, quantity and flooding matters (i.e. stormwater discharge prior to SEQ Cedar Grove weir, cumulative impacts of providing no detention, and other matters). Upon receiving these requests, Calibre provided letter responses and an update to the Concept Stormwater Management Plan Report (Concept SWMP, No. **B13343.W-02B** dated April 2017), which addressed these items. A list of relevant documents are provided in **Section 1.2**.

The objective of this report is to demonstrate that appropriate stormwater and flood management strategies have been adopted for ROL Stage 1 development, in accordance with the master planning strategies and in general compliance with the Queensland Governments Department of Infrastructure Local Government and Planning (DILGP) guidelines, Logan City Council's Planning Scheme (2015) and relevant best practice guidelines and standards.

The previous report (Issue B) was prepared to demonstrate that the stormwater and flood management strategies adopted for ROL Stage 1 development were in accordance with the master planning strategies and in general compliance with the relevant State and Local guidelines. Since the time of the Issue B submission the Queensland Governments Department of State Development, Manufacturing, Infrastructure and Planning have responded with Further Issues for PDA Development Application (Ref: DEV2017/901, dated 19/02/18). This issue (C) of the report has been prepared to address the stormwater related items of the Further Issues document. For details of the further issue items and Calibre's responses refer to **Section 1.3**. This issue also provides minor amendments in accordance with the updated site layout as presented in **Appendix A**.

1.1 Scope of this Report

The scope and framework of this report is as following:

- *Stormwater Management (Quantity)* – Hydrological analysis using XP-RAFTS was undertaken to determine the change in peak flows at each discharge location from the site as a result of the ROL Stage 1 development. For discharges to the main watercourse (south of ROL Stage 1), previous master planning analysis has demonstrated no adverse impact in the Logan River, therefore no detention is required for these discharges. Refer to **Section 3** of this report;
- *Waterway Stability Management* – In accordance with the master plan strategy, an end of line detention basin to the north and an online detention basin within the main watercourse (south of ROL Stage 1) is proposed to address the SPP's (2017) waterway stability management requirement. XP-RAFTS analysis was undertaken to determine if these measures are required during ROL Stage 1 development or whether they can be deferred to later stages. Refer to **Section 4** of this report;
- *Local Flooding* – As a portion of the main west-east drainage path (running through the master plan area) will be constructed in ROL Stage 1, refined XP-RAFTS and HEC-RAS modelling was undertaken to determine adequate channel design under 'ultimate' or overall masterplan development conditions. Refer to **Section 5** of this report;
- *Stormwater Management (Quality) & Total Water Cycle Management* –The master plan stormwater quality analysis (using MUSIC software) has been updated to confirm the adequacy of the proposed Stormwater Quality Improvement Devices (SQIDs) in ROL Stage 1 to meet Water Quality Objectives (WQO's) required under the State Planning Policy (SPP, 2017). Refer to **Section 6** of this report; and
- *Construction, Operational Management & Maintenance of SQIDs* – Details for construction, operational management and maintenance of stormwater quality improvement devices (SQIDs) is detailed in **Section 6.6**.

Other than the entrance road connecting Teviot Road to ROL Stage 1 (eastern site of Catchment O) and a small portion of the development in Catchment N, the northern parts of the master plan area are not being developed (i.e. Catchment M, N and O).Therefore details regarding the flow frequency have not been included in this report as they will be provided as part of future DA documentation involving these catchments. Also, since no filling of the Logan River floodplain is proposed in ROL Stage 1, Erosion, Sediment Control and Bank Stability Management is not required or (specifically) addressed in this report. General details on these areas of interest can be found in the master plan documentation.

1.2 Previous Documentation

The following indicates the latest master plan reports addressing stormwater and flood management:

- *Concept Stormwater Management Plan Report (Concept SWMP*, No. **B13343.W-02B** dated April 2017) – This report was updated following information requests from EDQ in January, 2017.
- *Flood Investigation Report* (No. **B13343.W-01B** dated November 2016) – No changes to the strategies and outcomes identified in this report were required as a result of EDQ's information request items.

The following documents have been submitted to EDQ in response to stormwater and flooding request items.

- Calibre's *Responses to Seqwater Advice letter* (Ref No. **B13343.W.09L.AMP.cm.docx** dated 16 March 2017) – provides an itemised summary of response to EDQ's Information Request (dated January 2017).
- Calibre's *Responses to EDQ Information Request letter* (Ref No. **B13343.W.10L.AMP.cm.docx** dated 20 April 2017) – provides an itemised summary of response to EDQ's Information Request (dated January 2017).
- •Calibre's *Cumulative Impact Assessment letter* (Ref No. **B13343.W.11L.AMP.cm.docx** dated 2 May 2017) – Cumulative Impact Assessment for Final Response to Item B-1 of Summary of Flood Investigation and Stormwater Management Review document (dated January 2017).

All past and current analyses have been undertaken generally in accordance with the following documents:

- *UDA Development Approval for MCU DEV2012/244 dated 12 September 2012 for 72 Riverbend Blvd, Cedar Grove;*
- *UDA Development Approval for MCU DEV2012/312 dated 21 November 2012 for 368 Bushman Dr, Jimboomba;*
- *Greater Flagstone Urban Development Area Development Scheme dated October 2011;*
- *EDQ Guideline 12 Park Planning (May 2015);*
- *EDQ Guideline 13 Engineering Standards (May 2015);*
- *EDQ Guideline 14 Environmental Values & Sustainable Resource Use (May 2015);*
- *EDQ Guideline 15 Protection from Flood and Storm (May 2015); and*
- *SEQ Water Development Guidelines (June 2012).*

1.3 Further Issue Response

This issue of the report (Issue C) has been prepared to respond to the stormwater items of the Queensland Government's Department of State Development, Manufacturing, Infrastructure and Planning *Further Issues for PDA Development Application for a PDA Development Permit for Reconfiguring a Lot* document (dated 19/02/18). The relevant stormwater items and a summary of Calibre's responses are presented below.

Item 6: The reduction in flow reported by the XP-RAFTS models appear potentially to be anomalous, in particular at upstream locations. Provide justification for the reported reductions in flow and confirm the range of storm durations considered for the assessment.

> **Response**: The reduction in peak flows is a result of the ROL development discharging flows earlier than under existing conditions. Hence, the peak flows from the upstream catchments and peak flows from the site no longer coincide resulting in a reduction of up to 5% in peak flows. This is demonstrated in **Table 4.3**, the reductions in peak flows occur from and downstream of the catchment which will be developed in stage 1. Further justification of the results have been provided in **Section 4.2.3**. The storm events considered for this assessment include the 63% AEP storm for 30, 45, 60, 90, 120 and 180 minute durations as detailed in **Section 4.2.2**.

Table 4.2 of the report provides developed case details for the west-east drainage path. Correct the table as the nominated catchment areas do not alter from the existing case.

Response: Discrepancies have been noted between the catchment areas documented in Section 4 and Drawing No's. **16-003350-SK206** & **SK207** in **Appendix H**. The ROL Stage 1- Discharge to West-East Drainage Path hydrological assessment has been updated to reflect the catchment characteristics presented in the aforementioned drawings. **Table 4.1**, **4.2** and **4.3** have been update to reflect the updated analysis.

Complete a waterway stability assessment for the west-east drainage path to confirm that the waterway will be sufficiently stable for the 63% AEP event and will not be subject to significant scour in larger events.

Response: A waterway stability assessment has been undertaken for the west-east drainage path as presented in **Section 4**. The assessment, undertaken for the ROL Stage 1 development has determined no increase in the 63% AEP flows as required under the SPP (2017). Furthermore, an energy dissipater and level spreader is proposed at the drainage outlet to diffuse concentrated flows.

Item 7: EDQ seeks compliance with water quality objectives nominated in the State Planning Policy. Revise the treatment system proposed for Precinct A to demonstrate compliance with the State Planning Policy.

Response: On review of the Precinct A stormwater quality model, it is noted the bioretention basin treatment nodes have not incorporated the overall bioretention basin surface areas, rather have adopted the proposed filter area of the surface area. When incorporating the required extended detention depths, freeboard and batter assumptions into the surface areas, the additional storage allows for a further reduction in TSS as more water is being treated. For further details of the bioretention basin surface areas and updated MUSIC modelling result, refer to **Section 6**.

Provide modelling results for Stage 1 and the treatment measures proposed to be constructed as part of Stage 1.

Response: As presented in **Section 6.6**, three bioretention basins are proposed within the Stage 1 development. Refer to **Figure 6.1** and Drawing No **16-003350-SK205** in **Appendix H** for the bioretention basin locations and details. The MUSIC modelling results for the Stage 1 development have been provided in **Section 6.6**.

Provide details of the level of imperviousness assumed for roads and ground areas.

Response: The roads and ground areas have been modelled with fraction impervious values of 70% and 24% respectively. The fraction impervious assumptions incorporated into the stormwater quality analysis have been provided in **Section 6.4.2**.

Please note that updates made to this report in response the further issue items have been highlighted as *Indented Italicised Text.*

2 Site Characteristics

2.1 Location

The master plan area is identified as Lots 101, 102, 105 & 106 on SP254145 and Lot 800 on SP247625. Geographically, the development will be located within the proposed Riverside Development Precinct and is bounded by Teviot Road and existing rural-residential allotments and associated infrastructure to the north and west, Logan River and associated tributaries to the south and existing rural-residential, associated infrastructure and former agricultural land to the east.

The overall development site is located within the Greater Flagstone Priority Development Area (PDA) within the Logan City Council Local Government Area (LGA). Reconfiguring of Lot Application 1 (ROL1 or Stage 1) is located centrally within the overall development precinct, refer **Figure 2.1**.

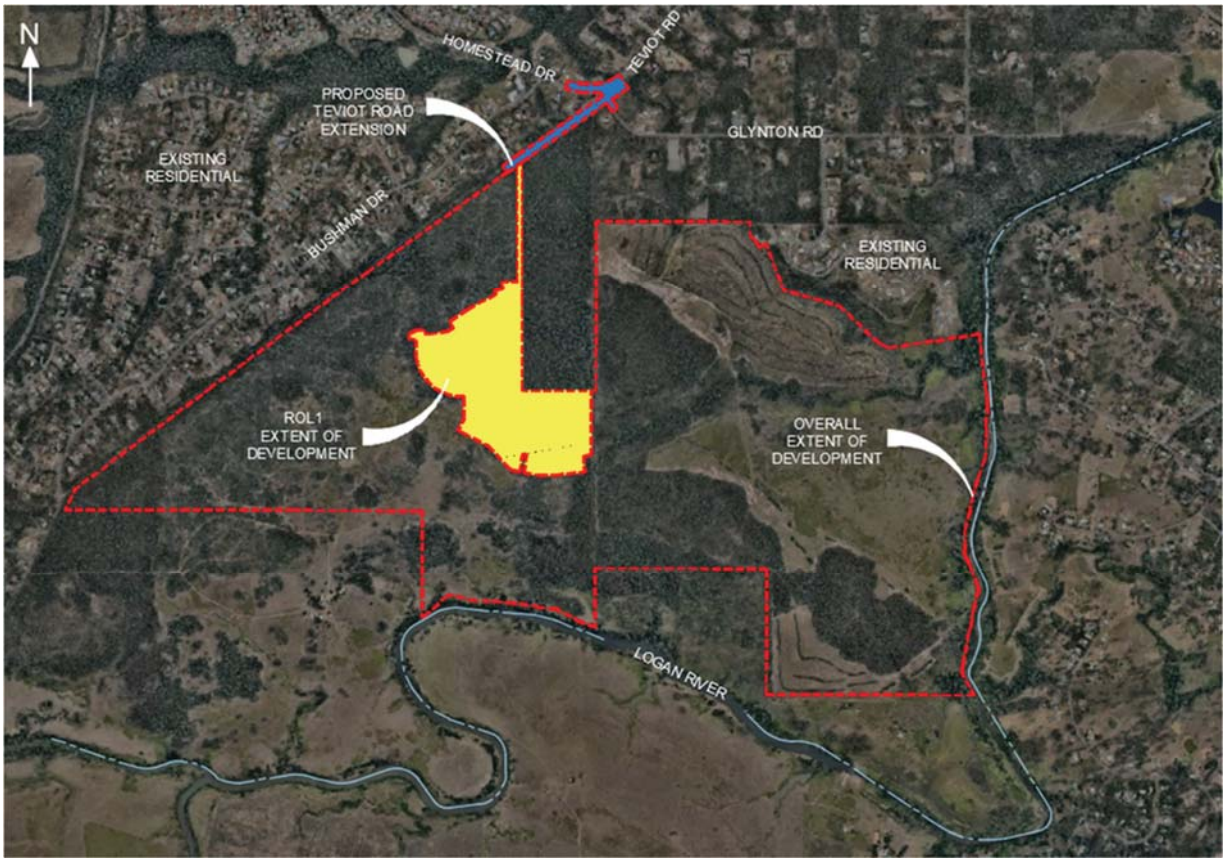

Figure 2.1 Locality Plan (Source: Google Earth)

2.2 Land Use

The ROL1 area contains a range of vegetation types including regrowth vegetation with a mixed grass and shrub understorey, cleared and grassland areas and pockets of riparian vegetation along the creek running east to west through the master plan area.

For the ROL Stage 1 development it is proposed to subdivide and construct 508 residential allotments, 1 super lot and associated infrastructure with the residential allotments ranging in size from 300m2 to 795m2. The total development ROL Stage 1 site area is 36.86ha. A road network will provide access from Teviot Road to the subdivision.

2.3 Existing Topography, Drainage & Flooding

The existing topography of the overall master plan site varies from RL 70m AHD in south-western corner, down to levels in the order of 25m AHD along the eastern side adjacent to Logan River. The eastern portion of the site is affected by flooding from Logan River.

The site, under existing conditions, predominately falls from west to east, however there are multiple other discharge points for the site. There are a number of local gullies within the site that connects to the main west-east drainage path. **Figure 2.2** below presents an image on the main west-east drainage path on site.

Figure 2.2 Existing Drainage Path on Site

There is no municipal drainage infrastructure on site nor private underground stormwater pipes. The runoff under existing conditions will follow the topography and discharge into either the river, Teviot Road or adjacent properties.

3 Stormwater Quantity

Hydrological analysis using XP-RAFTS has been undertaken to demonstrate no actionable nuisance from peak flows as a result of the ROL Stage 1 development. This has been undertaken in accordance with the overall master plan strategy as per Calibre's Concept SWMP (No. **B13343.W-02B** dated April 2017).

3.1 ROL Stage 1 - Peak Flow Mitigation Strategy

There are four main discharge locations for ROL Stage 1 (north of Teviot Road, two discharges across the eastern boundary into State Land - Lot 71 SL8963 and the west-east drainage path that discharges to the Logan River). Analysis has demonstrated that the following peak flow management measures (of the master plan strategy) outlined in **Figure 3.1** below are required for the development of ROL Stage 1.

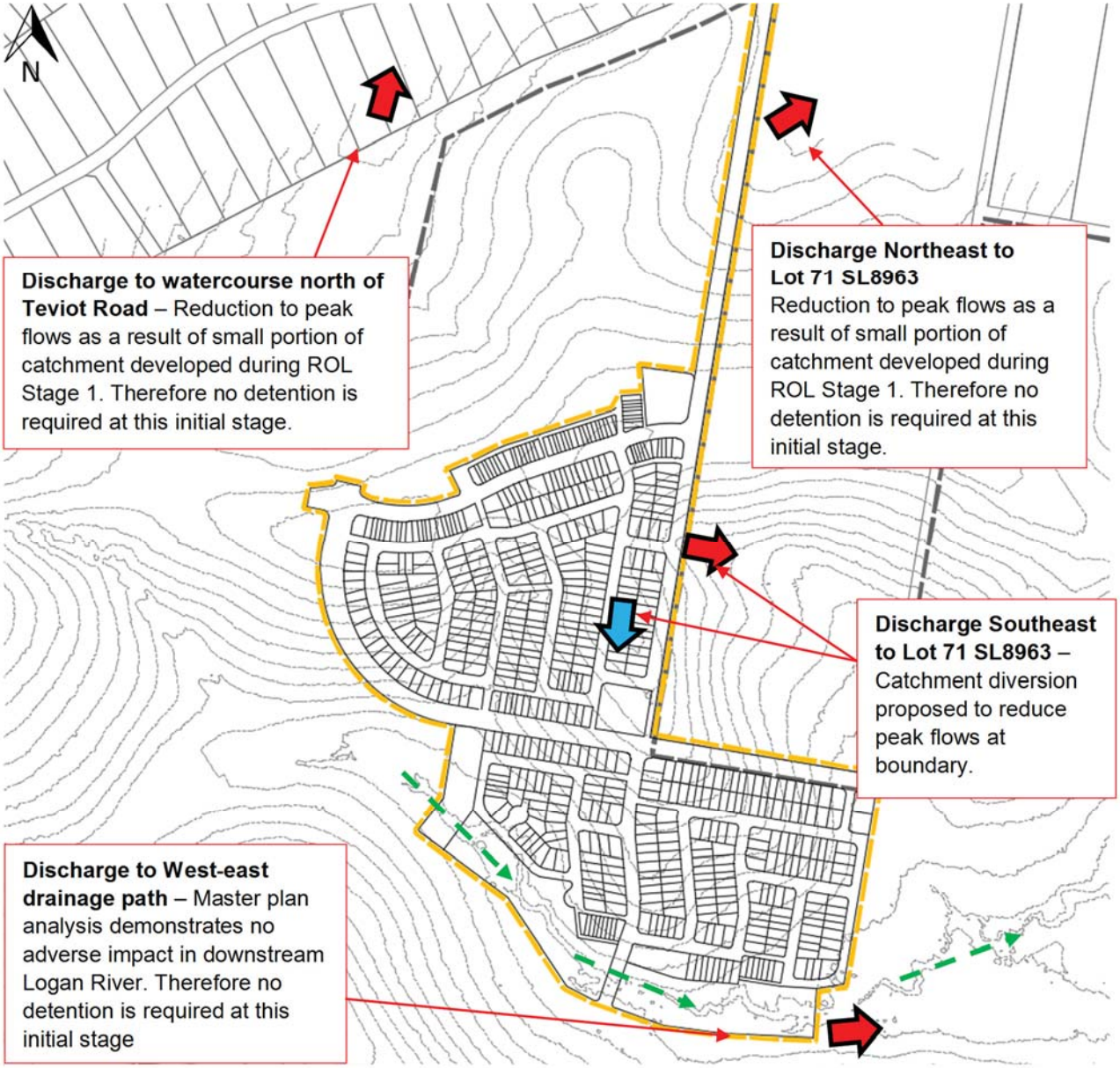

Figure 3.1 ROL STAGE 1 Peak Flow Management Strategy

The below summarises the peak flow management measures of the master plan strategy that are required for ROL Stage 1 development.

- *Discharge North of Teviot Road* – As a part of ROL Stage 1 only a small portion of the catchment discharging runoff north of Teviot Road (into an existing watercourse) will be developed (i.e. road). XP-RAFTS analysis has been undertaken (as discussed in Section 3.2) to confirm that there will be no increase in peak flows as a result of the small area of the development during ROL Stage 1. During the ROL of future stages, a detention basin will be required to reduce peak flows discharging to the north as per the master plan strategy.
- *Discharge Northeast to State Land (Lot 71 SL8963)* – As a part of ROL Stage 1 only a small portion of the catchment discharging runoff east across the site boundary into state land (into an existing watercourse) will be developed (i.e. the eastern boundary of the future school site). XP-RAFTS analysis has been undertaken in Section 3.3 to confirm that there will be no increase in peak flows as a result of the small area of the development during ROL Stage 1. During the ROL of future stages, a detention basin will be required to reduce peak flows discharging to the north as per the master plan strategy.
- *Discharge Southeast to State Land (Lot 71 SL8963)* – Under existing conditions there is a small catchment that discharges runoff across the site boundary into state land. It is proposed to divert a portion of this catchment runoff south towards the west-east drainage path to reduce peak flows back to or below existing conditions along the boundary. XP-RAFTS analysis has been undertaken (as discussed in Section 3.4) to confirm that there will be no adverse impact in Lot 71 as a result of the proposed catchment diversion.
- *Discharge to the west-east drainage path* – As per the master plan strategy a majority of the overall master plan area runoff is conveyed to an existing watercourse traversing west to east discharging into the Logan River. Analysis undertaken during the master planning phase demonstrates no adverse flood increases or impact within the Logan River as a result of the overall development without detention. Therefore no detention measures within the west-east drainage path are required for the overall master plan area or ROL Stage 1. To ensure no adverse flood impact from the proposed watercourse on the proposed ROL Stage 1 development, a local flooding assessment including XP-RAFTS and HEC-RAS analysis has been undertaken in Section 5. This analysis has determined adequate flood immunity for proposed ROL Stage 1 development.

Refer to Drawing No. **16-003350-SK205** in **Appendix H** for catchment details.

3.2 Discharge North of Teviot Road

XP-RAFTS analysis was undertaken to demonstrate that development of the small portion of Catchment N during ROL Stage 1 will not result in a peak flow increase or adverse impact for discharge to the north.

3.2.1 Catchment Data

Table 3.1 below indicates existing and ROL Stage 1 developed catchment areas and fraction impervious (Fi) values modelled in XP-RAFTS will not result in a peak flow increase or adverse impact to the north. As a detention basin will be required when more of the catchment discharging runoff to the north is developed in future stages, the sizing and configuration of the basin will be designed as part of these future stages.

Table 3.1 Existing and ROL Stage 1 Developed Catchment Data (Discharge North of Teviot Road)

Catchment	Existing Scenario		ROL Stage 1 Developed Scenario	
	Area (ha)	Fi Value	Area (ha)	Fi Value
M	20.4	0	20.4	0.01
N	18.0	0	18.0	0.07
Total	38.4	0	38.4	0.04

As indicated in the table above, development of the a portion of catchment M and N have resulted in an overall fraction impervious value of 4% for the catchment discharging to the north of Teviot Road.

3.2.2 XP-RAFTS Modelling Assumptions

All XP-RAFTS model parameters have been maintained as per the master plan analysis (refer to *Section 3.1* of the Concept SWMP, No. **B13343.W-02B** dated April 2017), which were verified to Rational Method calculations. The only changes to the previous modelling are the catchment details indicated in **Table 3.1**.

3.2.3 Results

A comparison between the existing and ROL Stage 1 developed results for discharges north of Teviot Road are indicated in **Table 3.2** below.

Table 3.2 Comparison of Peak Flows – Discharge North of Teviot Road

AEP	Existing Peak Flows (m^3/s)	ROL Stage 1 Peak Flows (m^3/s)	Percentage Difference (%)
63%	2.14	2.13	-0.5%
39%	3.26	3.25	-0.3%
20%	4.82	4.79	-0.5%
10%	5.82	5.78	-0.7%
5%	7.19	7.13	-0.9%
2%	8.88	8.81	-0.8%
1%	10.36	10.27	-0.9%

Results indicate a 0.5% to 0.9% reduction in peak flows as a result of the slight increase in impervious area. This is most likely a result of early discharge from the road and remaining area of the catchments not coinciding. This analysis demonstrates that no detention basin is required during the initial ROL Stage 1 development.

3.3 Discharge Northeast to State Land (LOT 71 SL8963)

XP-RAFTS analysis was undertaken to demonstrate that development of a small portion of Catchment O during ROL Stage 1 will not result in a peak flow increase or adverse impact for discharges to the north.

3.3.1 Catchment Data

Table 3.3 below indicates existing and ROL Stage 1 developed catchment areas and fraction impervious (Fi) values modelled in XP-RAFTS.

Table 3.3 Existing and ROL 1 Development Catchment Data (Northeast Discharge to Lot 71 SL8963)

Catchment	Existing Scenario		ROL Stage 1 Developed Scenario	
	Area (ha)	Fi Value	Area (ha)	Fi Value
O	9.96	0	9.72	0.14

As indicated in the table above, the ROL Stage 1 development results in a slight reduction in catchment area (due to earthworks that shifts the ridgeline to the south of Catchment O slightly) and slight increase in fraction impervious area.

3.3.2 XP-RAFTS Modelling Assumptions

All XP-RAFTS model parameters have been maintained as per the master plan analysis (refer to Section 3.1 of the Concept SWMP, No. **B13343.W-02B** dated April 2017), which were verified to Rational Method calculations. The only changes to the previous modelling are the catchment details indicated in Section 3.3.1.

3.3.3 Results

A comparison between the existing and ROL Stage 1 developed results for discharges to Lot 71 SL8963 from the future School site are indicated in **Table 3.4** below.

Table 3.4 Unmitigated ROL Stage 1 vs Existing Peak Flows – (Northeast Discharge to Lot 71 SL8963)

AEP	Existing Peak Flows (m^3/s)	ROL Stage 1 Unmitigated Peak Flows (m^3/s)	Percentage Difference (%)
63%	0.60	0.60	0%
39%	0.95	0.92	-3%
20%	1.38	1.33	-4%
10%	1.68	1.59	-5%
5%	2.08	1.97	-5%
2%	2.53	2.46	-3%
1%	2.93	2.88	-2%

Results indicate up to a 5% reduction in peak flows as a result of the ROL Stage 1 development only. This is most likely a result of the reduction in catchment area (caused by ROL Stage 1 earthworks) and the early discharge from the road that does not coincide with the peak of the overall catchment hydrograph. This analysis demonstrates no adverse impact and shows that no detention basin is required during the initial ROL Stage 1 development.

Under ultimate development conditions (i.e. future development of the School site and Catchment O) a detention basin will be required (as indicated in the master plan strategy). The proposed culvert structure (1800 x 900 RCBC) and minimum levels of the entrance road have been designed for ultimate conditions, which incorporates ultimate development overflows from the future basin control structure, water surface levels in the future detention basin and 20% blockage of culverts required by QUDM, 2017. An energy dissipater and/or level spreader is proposed at the culvert outlet to diffuse concentrated flows.

3.4 Discharge Southeast To State Land (Lot 71 SL8963)

XP-RAFTS analysis was undertaken to demonstrate that discharge to State Land on Lot 71 will be reduced as a result of the proposed catchment diversion. Details of modelling and results are provided in the sections below.

3.4.1 Catchment Data

Table 3.5 below indicates existing and ROL Stage 1 developed catchment areas and fraction impervious (Fi) values for discharges to Lot 71 SL8963, modelled in XP-RAFTS.

Table 3.5 Existing and ROL Stage 1 Developed Catchment Data (Southeast Discharge to Lot 71 SL8963)

Catchment	Existing Scenario		ROL Stage 1 Developed Scenario	
	Area (ha)	Fi Value	Area (ha)	Fi Value
W	3.24	0	1.85	0.8

As indicated in the table above, 1.4ha of catchment area (or 43% of the existing catchment) has been diverted towards the south to reduce peak flows into discharging to Lot 71 SL8963.

3.4.2 XP-RAFTS Modelling Assumptions

All XP-RAFTS model parameters have been maintained as per the master plan analysis (refer to Section 3.1 of the Concept SWMP, No. **B13343.W-02B** dated April 2017), which were verified to Rational Method calculations. The only changes to the previous modelling are the catchment details indicated in Section 3.4.1.

3.4.3 Results

A comparison between the existing and ROL Stage 1 developed results for discharges to Lot 71 SL8963 are indicated in **Table 3.6** below.

Table 3.6 Comparison of Peak Flows – Southeast Discharge to Lot 71 SL8963

AEP	Existing Peak Flows (m^3/s)	ROL Stage 1 Peak Flows (m^3/s)	Difference in Peak Flows (L/s)
63%	0.24	0.42	184
39%	0.37	0.56	192
20%	0.53	0.73	191
10%	0.64	0.83	188
5%	0.79	0.97	179
2%	0.96	1.08	120
1%	1.11	1.21	100

Results indicate a slight increase in peak flows (100 to 184L/s), even with 43% of the catchment area diverted to the south. Manning's calculations were undertaken to determine the impact of up to 184L/s increase. Results are indicated in **Table 3.7** below. Manning's calculation summaries are provided in **Appendix C**.

Table 3.7 Comparison of Flood Levels and Velocities at Boundary adjacent to Lot 71 SL8963

AEP	Change in Flood Levels (mm)	Change in Velocity (m/s)	Developed Scenario Velocity (m/s)
63%	+40mm	+0.09m/s	0.7 m/s
5%	+20mm	+0.04m/s	0.8 m/s
1%	+10mm	+0.02m/s	0.9 m/s

As indicated in **Table 3.7** the increase in peak flows results in a maximum 10mm increase in flood levels in the 1% AEP storm and 40mm during the 63% AEP storm. While velocities increase by 0.09m/s in the 63% AEP storm, velocities up to the 1% AEP storm are low, below 1m/s. Peak velocities of 0.7m/s to 0.9m/s typically do not result in scour within a vegetated channel. Therefore the slight increase in flows will not result in an adverse impact. An energy dissipater and level spreader is proposed at the drainage outlet to diffuse concentrated flows.

The analysis provided above, indicates insignificant increases to flood levels or velocities within Lot 71, which further demonstrates no adverse impact.

3.5 Summary of Peak Flow Analysis

The below summarises the outcomes of the peak flow analysis.

- *Discharge North of Teviot Road* – XP-RAFTS analysis indicates a 0.5% to 0.9% reduction in peak flows as a result of early discharge and non-coincidental peaks. As such, this demonstrates no adverse impact and therefore detention is not initially required for discharges to the north during ROL Stage 1 development.
- *Northeast Discharge to State Land (Lot 71 SL8963)* – XP-RAFTS analysis indicates up to 5% reduction in peak flows as a result of the slight reduction in catchment area, early discharge of impervious areas and non-coincidental peaks. As such, no adverse impact has been demonstrated and therefore detention is not initially required for discharges to the north east during ROL Stage 1 development.
- *Southeast Discharge to State Land (Lot 71 SL8963)* – XP-RAFTS analysis demonstrates a slight increase in peak flows (up to 184L/s in 1% AEP event), even with the 1.4ha or 43% of the catchment diverted south. Manning's calculations for a section along the site boundary indicate that this slight increase in peak flows will only result in a maximum 40mm increase in flood levels or 0.1m/s increase in velocities. These small increases will not be perceivable let alone adverse. Therefore analysis demonstrates that no adverse impact will be achieved for discharges to Lot 71.
- *Discharge to the west-east drainage path* – As per the master plan analysis no peak flow mitigation is required for discharges to the west-east drainage path and towards the Logan River is required.

4 Waterway Stability Management

As part of the design objectives of the SPP (2017) for urban stormwater management, developments are required to achieve the waterway stability management criteria. The aim of the waterway stability management is to reduce the impacts of urban development on channel bed and bank erosion by limiting changes in flow rate and duration within receiving waters.

This Section has been updated to address Items 6 of the Queensland Government's Further Issue letter dated February 2018, specifically the following:

- *Further details have been provided in **Section 4.2.3** to justify the reduction in peak flows from existing conditions;*
- *Details of the storm events modelled during the hydrological assessment have been provided in **Section 4.2.2**; and*
- ***Table 4.1**, **4.2** & **4.3** and the hydrological analysis has been amended to ensure consistency between analysis and documentation. Refer to **Section 4.2.1** and **4.2.3** for the updated catchment areas.*

4.1 ROL Stage 1 – Waterway Stability Requirements

The following analysis has been undertaken for discharges from ROL Stage 1 development to demonstrate compliance with waterway stability requirements:

- *Discharge North of Teviot Road* – As indicated in the XP-RAFTS analysis provided in **Section 3.1** there is a 0.5% reduction in 63% AEP peak flows as a result of the development of the entrance road (the extent of ROL Stage 1 works in Catchment M and N). This addresses waterway stability management requirements.

  Further to this, future measures are proposed to reduce the prevalence of saturated soils and wet ground conditions near Teviot Road. To reduce the frequency of low flows in the future and improve soil and ground conditions near Teviot Road, there is a potential to integrate a natural pond in the base of the future entrance detention basin. This would provide some storage and reduce the frequency of low flows discharging to Teviot Road. Furthermore, as indicated in **Section 6**, rainwater tanks proposed for development areas discharging to the north will also provide initial capture of frequent roof flows.
- *Discharge Northeast to State Land (Lot 71 SL8963)* – As indicated in the XP-RAFTS analysis provided in **Section 3.3**, there is no increase in 63% AEP peak flows as a result of the ROL Stage 1 development. This addresses waterway stability management requirements.
- *Discharge Southeast to State Land (Lot 71 SL8963)* – As indicated in the analysis provided in **Section 3.4**, there is less than 40mm increase in flood levels and low velocities (below 1m/s) are maintained during the 63% AEP, as a result of the proposed development and catchment diversion. These increases are not considered as significant to cause channel bed or bank erosion. Furthermore an energy dissipater and/or level spreader is proposed downstream of the catchment discharge point to diffuse concentrated flows. Therefore waterway stability management requirements have been demonstrated.
- *Discharge to the west-east drainage path* – XP-RAFTS analysis in **Section 4.2** to determine the impact of developed ROL Stage 1 only on the west-east drainage path. Results demonstrate a reduction in peak flows under ROL Stage 1 developed conditions. Therefore the online detention proposed as part of the master plan to mitigate 63% AEP peak flows in the watercourse is not required for the initial ROL Stage 1 development.

The above waterway stability requirements are summarised in **Figure 4.1** below.

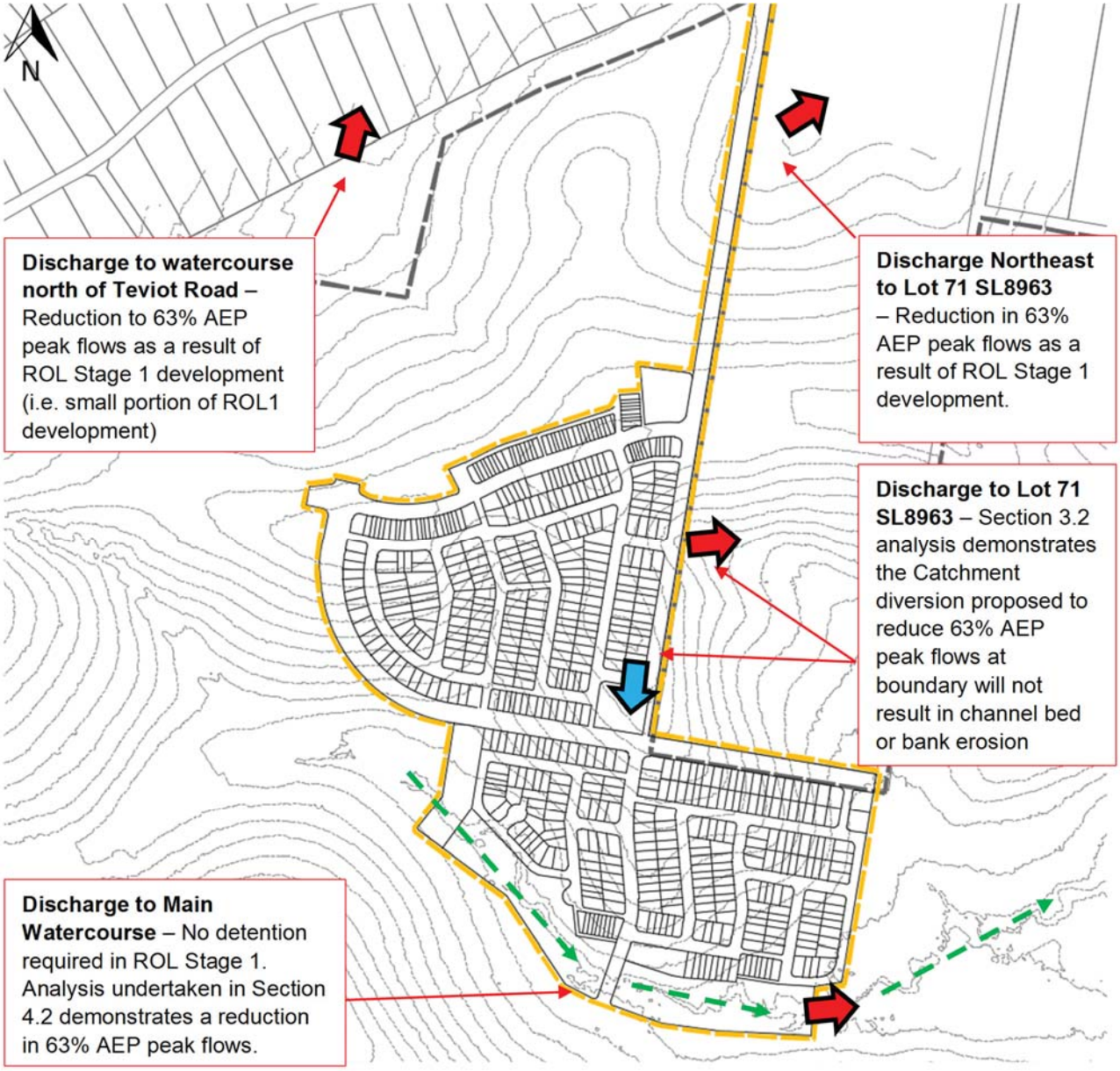

Figure 4.1 ROL Stage 1 Waterway Stability Requirements

4.2 ROL Stage 1 – Discharge To West-East Drainage Path

XP-RAFTS analysis was undertaken to assess the change in 63% AEP peak flows through the west-east drainage path as a result of ROL Stage 1 development only.

4.2.1 Catchment Data

This Section has been updated to address Items 6 of the Queensland Government's Further Issue letter dated February 2018.

Table 4.1 below indicates updated details for the existing model for catchments discharging to the west-east drainage path. Since the master plan analysis the vectored slope and routing has been refined to reflect varying slopes within the catchments. Existing Catchment Boundaries are provided on Drawing No. **16-003350-SK206** in **Appendix H** for catchment delineation.

Table 4.1 Existing Catchment Details to West-East Drainage Path

Catchment Name	Catchment Area (ha)	Fraction Impervious	Vectored Slope	Pervious Manning's n
U1	31.64	0%	2.95	0.06
U2	13.36	0%	5.27	0.06
U3	16.25	0%	8.9	0.06
U4	33.47	0%	6.58	0.06
U5	4.92	0%	7.18	0.06
U6	17.03	0%	6.56	0.06
U7	43.54	0%	6.41	0.06
U8	45.87	0%	6.54	0.06
U9	25.82	0%	5.03	0.06
U10	26.12	0%	5.08	0.06
U11	15.73	0%	4.61	0.06
U12	9.39	0%	2.47	0.06
U13	56.54	0%	3.27	0.06
U14	30.00	0%	2.99	0.06
Total	369.68	0%	-	-

***Table 4.1** was updated to ensure consistency with the catchment areas shown on **16-003350-SK206**.*

Table 4.2 below indicates catchment details for the ROL Stage 1 developed scenario. Vectored catchment slope and routing will not be significantly changed during ROL Stage 1 development, therefore these have remained as per existing conditions. Changes have been highlighted in bold. Refer to Drawing No. **16-003350-SK208** in **Appendix H** for catchment delineation.

Table 4.2 ROL Stage 1 Developed Catchment Details to West-East Drainage Path

Catchment Name	Catchment Area (ha)	Fraction Impervious	Vectored Slope	Pervious Manning's n
U1	31.64	0	2.95	0.06
U2	13.36	0	5.27	0.06
U3	16.25	0	8.9	0.06
U4	33.51	0	6.58	0.06
U5	4.98	0	7.18	0.06
U6	22.64	0.62	6.56	0.06
U7	43.51	0.28	6.41	0.06
U8	40.98	0.05	6.54	0.06
U9	25.82	0	5.03	0.06
U10	26.12	0	5.08	0.06
U11	15.73	0	4.61	0.06
U12	9.39	0	2.47	0.06
U13	56.54	0	3.27	0.06
U14	30.00	0	2.99	0.06
Total	370.47	0.07	-	-

Table 4.2 *was updated to ensure consistency with the catchment areas shown on* ***16-003350-SK207***.

4.2.2 XP-RAFTS Modelling Assumptions

All other XP-RAFTS model parameters have been maintained as per the master plan analysis (refer to **Section 3.1** of the Concept SWMP, No. **B13343.W-02B** dated April 2017), which were verified to Rational Method calculations. The only variation from the previous modelling is indicated in **Section 4.2.1.**

Analysis was undertaken for the 63% AEP storm event for 30, 45, 60, 90, 120 and 180 minute durations.

4.2.3 Results

A comparison between the existing and ROL Stage 1 developed results for discharges through the west-east drainage path are indicated in **Table 4.3** below.

Table 4.3 Existing and ROL Stage 1 Developed 63% AEP Peak Flows in West-East Drainage Path

Catchment Name	Existing Peak Flows (m3/s)	ROL Stage 1 Developed Peak Flows (m3/s)	Percentage Difference (%)
U1	1.33	1.33	0%
U2	2.01	2.01	0%
U3	2.97	2.97	0%
U4	4.86	4.87	0%
U5	5.12	5.12	0%
U6	6.05	6.06	0%
U7	8.10	7.78	-4%
U8	10.20	9.66	-5%
U9	11.33	10.85	-4%
U10	12.37	11.95	-3%
U11	12.94	12.57	-3%
U12	13.29	12.95	-3%
U13	15.39	15.06	-2%
U14	16.39	16.10	-2%

Table 4.3 *was updated to present the updated XP-RAFTS results in accordance with the updated catchment areas as documented in* **Table 4.1** *and* **Table 4.2**.

Results indicate a 0% to 5% reduction in peak flows as a result of the ROL Stage 1 development. This is most likely a result of the early discharge of ROL development (peak flow levels not coinciding) and only a small portion of the west-east drainage path catchment being developed as part of ROL Stage 1. This analysis demonstrates that the proposed detention basin for waterway stability is not required during the initial ROL Stage 1 development.

5 Local Flooding

The local flood investigation (undertaken for master plan analysis) has been updated to determine appropriate flood levels and flood immunity levels for proposed lots adjacent to the west-east drainage path (traversing the site from west to east). The west-east drainage path has been designed for fully developed master plan conditions. However, an interim ROL Stage 1 scenario has been undertaken to inform staging of works within the west-east drainage path.

This section will provide the following:

- **Section 5.1**: Objectives – The flood immunity objectives are indicated as identified in the master plan submission and in accordance with LCC and PDA guidelines.
- **Section 5.2**: ROL Stage 1 ¬Developed Scenario – Hydrological results from the model developed in Section 4.2 was input in the ROL Stage 1 developed HEC-RAS model to determine flood levels. A sensitivity check was undertaken assuming a high Manning's n value of 0.15.
- **Section 5.3**: Fully Developed Future Scenario – XP-RAFTS analysis was undertaken for a fully developed catchment to the west-east drainage path. Peak flow results were input in the HEC-RAS model to determine flood levels in the future fully developed conditions. A sensitivity check was undertaken assuming a high Manning's n value of 0.15. Flood immunity levels for ROL Stage 1 development adjacent the west-east drainage path (i.e. from HEC-RAS Section 2096 to 3220) was determined.

5.1 Flood Immunity Objectives

Flood immunity standards are indicated in **Table 5.1** below, as identified in the master plan investigations. The habitable floor flood immunity is in accordance with LCC guidelines as required under *Table 1* of the *PDA Guideline No. 15 Protection from Flood and Storm Tide Inundation* (2015). The park flood immunity standards are in accordance with *Table 5* of the *PDA Guideline No. 12 Park Planning and Design* (2015).

Table 5.1 Flood Immunity Standards

Floor Type	Flood Immunity Standard
Habitable Floor	Greater of: • 1% AEP + 500mm or • Sensitivity Scenario
District Sports Park Buildings	1% AEP (Sensitivity Scenario)
District Sports Park Sports Fields	5% AEP
Recreation Park Buildings	1% AEP (Sensitivity Scenario)
Recreation Park[1]	20% AEP

[1] 30% of the recreation park area can be below 20% AEP flood level

While LCC's *Flood Hazard Overlay Code* (2015) only specifies freeboard requirements to habitable floor levels, the design has adopted that allotment ground levels be provided above the greater of 1% AEP + 300mm or sensitivity scenario flood levels.

Both the regional and local flood levels need to be considered for nominating the flood immunity standards. Regional flood levels have been determined in Calibre's Flood Investigation Report (No. **B13343.W-01B** dated November 2016).

5.2 ROL Stage 1 Developed Scenario

HEC-RAS modelling for the ROL Stage 1 developed scenario was undertaken to demonstrate that the proposed works within the west-east drainage path is adequate for achieving the required flood immunity levels. HEC-RAS modelling is focused on the portion of the west-east drainage path adjacent to ROL Stage 1 development (i.e. from HEC-RAS Section 2135 to 3269).

5.2.1 Hydrological Input

Hydrological results from the XP-RAFTS model discussed in **Section 4.2** was input in the ROL Stage 1 developed HEC-RAS model to determine flood levels. Refer to Drawing No. **16-003350-SK207** in **Appendix H** for catchment details. **Table 5.2** below indicates peak flow input used at critical cross sections.

Table 5.2 1% AEP Peak Flow Input

HEC-RAS Cross Section	Downstream Catchment	Peak Flow Input (m3/s)
3432	U3	14.0
3255	U4	20.7
3243	U5	21.5
2956	U6	24.7

5.2.2 HEC-RAS Modelling

The HEC-RAS modelling undertaken for the master plan analysis has been updated and refined for ROL Stage 1 developed scenario. The following assumptions were adopted, in line with master plan analysis:

- Upstream Boundary Condition: Normal depth friction slope of 0.78%;
- Downstream Boundary Condition: Tail Water Level of 26.25m AHD (10% AEP Logan River flood level).
- Manning's n: value of 0.06 was adopted (this is higher and more conservative than the master plan analysis assumption)
- Longitudinal Slope of the west-east drainage path is generally as per the existing slope.
- Obstructions were modelled for future development to the south conservatively.
- Concept culvert crossings were modelled conservatively (these will be designed and constructed in future stages)

Concept design of the watercourse adjacent ROL Stage 1 has been integrated with concept bulk earthworks and undertaken using 12D. Refer to Drawing No. **16-003350-SK202** for a typical cross section of the west-east drainage path design.

A sensitivity scenario using a Manning's n value of 0.15 was also undertaken.

5.2.3 Results

1% AEP flood levels are indicated in **Table 5.3** below for the west-east drainage path section adjacent to ROL Stage 1.

Table 5.3 HEC-RAS 1% AEP Flood Level Results

HEC-RAS Cross Section	ROL Stage 1 Developed 1% AEP Flood Level (m AHD) n=0.06	ROL Stage 1 Developed 1% AEP Flood Level (m AHD) n=0.15 (Sensitivity)
3269	40.53	40.98
3255	40.39	40.87
3243	40.24	40.74
3199	39.73	40.21
3158	39.22	39.72
3098	38.51	38.99
3041	37.78	38.28
2982	37.12	37.64
2956	36.83	37.37
2938	36.62	37.18
2907	36.39	36.90
2870	35.98	36.54
2839	35.69	36.32
2803	35.60	36.18
2766	35.57	36.12
2747	35.47	36.04
2726	35.42	35.93
2707	35.38	35.86
2681	35.26	35.72
2645	34.79	35.35
2611	34.39	35.00

2575	34.06	34.63
2553	Culvert Crossing	-
2531	34.08	34.57
2483	33.85	34.25
2431	32.88	33.62
2392	32.62	33.22
2352	32.56	33.08
2312	32.45	32.94
2290	32.36	32.85
2254	32.26	32.70
2222	32.18	32.57
2195	32.09	32.43
2178	31.85	32.32
2159	31.82	32.20
2135	31.75	32.08

Results in **Table 5.3** indicate flood levels when ROL Stage 1 is developed. In order to set adequate flood immunity levels (as per **Section 5.1**) a fully developed catchment (of the overall master plan area) needs to be assumed. This analysis has been undertaken in the following section.

5.3 Fully Developed Future Scenario

HEC-RAS modelling for the fully developed future scenario was undertaken to determine required flood immunity levels. Modelling is focused on the portion of the west-east drainage path adjacent to ROL Stage 1 development (i.e. from HEC-RAS Section 2135 to 3269).

5.3.1 Hydrological Input

The ROL Stage Developed Scenario XP-RAFTS model was updated to reflect fully developed conditions of the upstream catchment. This was based on the development of the entire site within the master plan area. Refer to Drawing No. **16-003350-SK208** in **Appendix H** for future catchment details. **Table 5.4** below indicates peak flow input used at critical cross sections.

Table 5.4 Peak Flow Input – Fully Developed Scenario

HEC-RAS Cross Section	Downstream Catchment	1% AEP Peak Flow Input (m3/s)	5% AEP Peak Flow Input (m3/s)
3432	U3	34.9	29.2
3255	U4	44.4	36.3
3243	U5	54.0	44.1
2956	J_U5	66.3	54.0
2483	U6	62.6	50.3
2290	U7	64.6	50.1

5.3.2 HEC-RAS Modelling

Other than the change in peak flow input, the setup of the HEC-RAS model for future developed scenario remains as per the ROL Stage 1 Developed Scenario (refer to **Section 5.2.2**).

5.3.3 Results

1% AEP flood levels are indicated in **Table 5.5** below for the west-east drainage path section adjacent to ROL Stage 1. Minimum allotment levels were determined by the adopting the maximum of the fully developed flood level + 300mm freeboard or the high Manning's sensitivity scenario (the greater of the two).

Table 5.5 HEC-RAS 5% and 1% AEP Flood Level Results for Fully Developed Scenario

HEC-RAS Cross Section	Fully Developed Future 5% AEP Flood Level (m AHD) n=0.06	Fully Developed Future 1% AEP Flood Level (m AHD) n=0.06	Fully Developed Future 1% AEP Flood Level (m AHD) n=0.15	Minimum Habitable Allotment Level
(m AHD)				
3269	40.89	41.03	41.74	41.74
3255	40.79	40.93	41.66	41.66
3243	40.61	40.74	41.53	41.53
3199	40.09	40.22	41.01	41.01
3158	39.59	39.72	40.51	40.51
3098	38.87	38.99	39.79	39.79
3041	38.14	38.27	39.11	39.11

2982	37.56	37.71	38.48	38.48
2956	37.27	37.42	38.22	38.22
2938	37.07	37.22	38.02	38.02
2907	36.83	36.99	37.76	37.76
2870	36.43	36.58	37.48	37.48
2839	36.26	36.43	37.30	37.30
2803	36.16	36.34	37.17	37.17
2766	36.13	36.30	37.08	37.08
2747	35.95	36.10	36.98	36.98
2726	35.90	36.05	36.88	36.88
2707	35.85	36.00	36.80	36.80
2681	35.71	35.85	36.66	36.66
2645	35.27	35.55	36.43	36.43
2611	35.08	35.45	36.26	36.26
2575	34.83	35.26	36.03	36.03
2553	Culvert Crossing	-	-	-
2531	34.48	34.62	35.32	35.32
2483	34.23	34.38	34.89	34.89
2431	33.37	33.52	34.32	34.32
2392	33.06	33.22	33.96	33.96
2352	32.98	33.12	33.78	33.78
2312	32.83	32.97	33.61	33.61
2290	32.75	32.90	33.50	33.50
2254	32.60	32.73	33.34	33.34

2222	32.47	32.60	33.17	33.17
2195	32.34	32.45	33.00	33.00
2178	32.20	32.32	32.86	32.86
2159	32.12	32.23	32.72	32.72
2135	31.99	32.09	32.55	32.55

Note that the regional flood level is 30.85m AHD and is not the critical flood level for flood immunity in ROL Stage 1.

Results in **Table 5.5** indicate that the high Manning's sensitivity scenario flood levels generally dictate flood immunity levels for habitable floor levels. It is noted that the modelled sensitivity scenario is very conservative and it is unlikely that flood levels would reach the indicated levels. This is because an overgrown channel with high Manning's value is also likely to slow down and reduce peak flows (which was not taken into account in the peak flow input; high peak flows were maintained conservatively).

Flood extents in the fully developed future scenario for the 5% AEP, 1% AEP and 1% AEP Sensitivity Scenario are indicated on Drawing No. **16-003350-SK209** and **SK210** provided in **Appendix H**. Minimum allotment levels have also been indicated on these plans.

6 Stormwater Quality & Total Water Cycle Management

This Section has been updated to address Items 7 of the Queensland Government's Further Issue letter dated February 2018, specifically the following:

- *The Precinct wide stormwater quality model was updated to incorporate the overall bioretention basin surface areas (incorporating batters and extended detention depth). The refined model demonstrates the WQO's can be met in accordance with the State Planning Policy. Refer to **Section 6.5** for the amended modelling results;*
- *Refer to **Section 6.6** for the treatment measures proposed to be constructed as part of Stage 1. The Stage 1 modelling results have been provided in **Section 6.6.**1; and*
- *Further details of the fraction impervious assumptions made in the MUSIC modelling have been provided in **Section 6.4.2**.*

To improve the quality of the runoff leaving the site, a treatment train incorporating Stormwater Quality Improvement Devices (SQIDs) is proposed. SQIDs will intercept and capture pollutants so that any potential stormwater quality impacts from the site will be mitigated and the required WQOs will be achieved. Roof water and stormwater harvesting is proposed for achieving an integrated total water cycle management solution.

MUSIC analysis has been undertaken for the overall master plan area, as per Calibre's Concept Stormwater Management Plan Report (No. **B13343.W-02B** dated April 2017). The overall master plan stormwater quality management strategy has been accepted by EDQ.

Since this submission, the semi-offline wetland proposed for MUSIC Catchment U has been removed from the strategy. As ongoing amendments to the original stormwater quality management strategy may occur as the design progresses, it is proposed the site achieve the Living Waterways outcomes. Living Waterways is a best practice environmental management approach to delivering enduring, engaging and affordable places supported by Healthy Waterways and aligned with the State Planning Policy (2017). – Matt, Please have a read, I don't want to take out the living waterways parts of this report as I will have to rewrite the whole quality section. I have attempted to provide some reason to our 4 pages of living water ways rambling now that we actually meet WQO's

To address Living Waterways outcomes, the overall master plan area has been split into three "Stormwater Quality Precincts" (SWQ Precinct A, B and C) as detailed below.

- SWQ Precinct A – incorporates MUSIC Catchments F, M, N, O, R, U and W;

- SWQ Precinct B – incorporates MUSIC Catchments D, G, H, I, K, L, V; and
- SWQ Precinct C – incorporates MUSIC Catchments A, B, C, E, P, Q, S, T.

The SWQ precincts have been indicated on Drawing No. **16-003350-SK204** in **Appendix H**.

Since ROL Stage 1 only involves development of MUSIC Catchment M, N and R, only the assessment of SWQ Precinct A has been addressed in this report. Details of other SWQ Precincts will be provided during future ROL stages.

This section has been structured with the following framework.

- **Section 6.1** – Living Waterways – Stormwater Quality Precinct A;
- **Section 6.2** – Water Quality Objectives;
- **Section 6.3** – Stormwater Quality & Total Water Cycle Management Strategy;
- **Section 6.4** – MUSIC Modelling Methodology; and
- **Section 6.5** – Precinct A MUSIC Model Results.

6.1 Living Waterways – Stormwater Quality Precinct A

- The Living Waterways Approach Framework aims to align the values that motivate traditional stormwater principles with place-making and liveability benefits for the community. The Framework incorporates a rating system with credit points attributed to outcomes. A number of outcomes are mandatory and are required to be complied with to be eligible for the final rating. The rating system is built around four themes:
- Living Water;
- Living Places;
- Living Communities; and
- Living Local Economies.

The Framework has been incorporated to aid in meeting state planning policies, community goals and expectations for the site. The Framework complies with the SPP (2017): Water Quality as this is a regionally, local and site appropriate solution to achieve protection and enhancement of the environmental values. This framework is an alternative solution for achieving the performance outcomes of the SPP (2017): Water Quality.

A table summarising the framework, the recommended approach to comply with the framework and the specific actions required to comply with and achieve sufficient credit points for a rating is provided in **Appendix E**.

The suite of outcomes ensures developments balance the four pillars of environmental, economic, cultural and social community outcomes at the site level by influencing development of sites during the design, development and construction phases.

- 1 Drop Rating = 36 to 40 credits
- 2 Drop Rating = 41 to 54 credits
- 3 Drop Rating = 55 credits and above

A “1 Drop Rating” achieves the SPP objectives or best practice management criterion.

Living Waterways is an innovative new approach with the potential to achieve multiple benefits for all involved. It is intended that this model will evolve and adapt to enable the broadest possible use and application.

A number of the outcome objectives require site specific development and landscaping design elements. The inclusion of these landscape design elements will provide credit points that could offset the runoff pollution requirements, hence minimising the size and complexity of WSUD devices required. Additional consideration is given for low maintenance, interactive and resilient design outcomes.

A table summarising the Living Waterways outcomes and credits achieved through proposed measures is provided in **Appendix E**.

6.2 Water Quality Objectives

Typical key pollutants expected to be generated during the operational (post-construction) phase of an urban development are listed as follows, with those presented in capitals being the key pollutants to be targeted for treatment:

- LITTER
- SEDIMENT
- Oxygen demanding substances (possibly present)
- NUTRIENTS (Nitrogen & Phosphorus)
- Pathogens / Faecal coliforms
- Hydrocarbons
- HEAVY METALS (associated with fine sediments)
- Surfactants
- Organochlorines & organophosphates
- Thermal pollution
- pH altering substances

Only the key pollutants will be further addressed in this report; however, the treatment train developed will adequately mitigate the other pollutant loads. As heavy metals will predominately be associated with fine sediment, controls proposed to reduce total suspended solids will also adequately reduce loads of heavy metals.

The load reduction WQOs presented in **Table 6.1** have been adopted from *Appendix 3* of the *SPP (2017).*

Table 6.1 Water Quality Objectives – Typical SPP 2017 Target

Pollutant	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Gross Pollutants
Load Reduction Target	80%	60%	45%	90%

In addition to the above WQOs, the following SEQ Water *Development Guidelines* (June 2012) requirements for water sensitive urban design and stormwater/runoff management have also been addressed.

As indicated in **Section 6.1**, the development has been assessed as per the Living Waterways Framework to offset the slight shortfall in TSS as a result of removing the semi-offline wetland in Catchment U. Various criterion to address enhancement of the downstream waterway has been identified in Living Waterways Summary Table in **Appendix E**.

Living Waterways credit points are available depending on the pollutant reduction achieved, as per **Table 6.2** below.

Table 6.2 Water Quality Objectives – Living Waterways Credits

	Pollutant	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Gross Pollutants
1	Load Reduction Target To achieve 8 Credit Points	80%	60%	45%	90%
2	Living Waterways Pollutant Load 25% above Target (LW1.2 - 12 Credits)	85%	70%	58.75%	92.5%
3	Living Waterways Pollutant Load 50% above Target (LW1.2 - 2 Credits)	70%	40%	17.5%	90%

6.3 Stormwater Quality & Total Water Cycle Management Strategy – SWQ Precinct A

For SWQ Precinct A, the following Stormwater Quality Improvement Devices (SQIDs) are proposed:

- Bioretention systems at all discharge locations on the west-east drainage path, school zone and Teviot Road; and
- Rainwater tanks for commercial areas, the school and medium density residential (25 dwellings/ha) areas of Catchments M, N and O in future ROL stages. These are proposed as part of the total water cycle management strategy and to reduce frequent flows discharging towards Teviot Road. As discussed in Section 4.1 this will also reduce the prevalence of saturated soils and wet ground conditions near Teviot Road.

Note that the semi-offline wetland for Catchment U has been removed. This is to enhance area for the district sports park for community benefit. Living Waterways outcomes have been achieved through specific design measures. These are listed below, but are not limited to:

- Accessible stormwater management features (stepping stones incorporated in bioretention basin).
- Vegetated swales for low flows into bioretention basins.
- Nature trails along the proposed & existing watercourse for outdoor wild experiences.
- Integrated educational features.
- Bioretention basins with enhanced amenity through landscaping.
- Utilising local trees and vegetation.
- Rehabilitation of sections of the watercourse.
- Inclusion of social features such as BBQ Areas and social spaces.
- Outdoor seating onlooking natural pool and riffle systems.
- Walking and cycling tracks for healthy living.

Refer to Drawing No. **16-003350-SK205** in **Appendix H** for the stormwater quality catchment delineation for SWQ Precinct A. SQIDs constructed during ROL Stage 1 are indicated on Drawing No. **16-003350-SK200**.

Living waterways features are detailed in the Living Waterways Summary Table and Drawing No. **16-003350-SK104** and -**SK105** in **Appendix H**.

6.4 Music Modelling Methodology

Water quality modelling has been undertaken using MUSIC Version 6.2, developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH). MUSIC enables the user to conceptualise the transfer of pollutants through a stormwater drainage system and provides an aid in quantifying the effectiveness of the proposed stormwater quality treatment train. MUSIC only provides quantitative modelling for Total Suspended Solids (TSS), Total Phosphorous (TP), Total Nitrogen (TN) and Gross Pollutants (GP).

The MUSIC model was setup in accordance with Water by Design *MUSIC Modelling Guidelines* (2010).

6.4.1 Meteorological Data

Six minute pluviographic data was sourced from the eWater website for Greenbank Thompson Road (Station No. 040659).

In accordance with Table 3.1 from *MUSIC Modelling Guidelines* (2010), the 10 year period from 1 January 1980 to 31 December 1989 has been adopted for the rainfall duration. The mean annual rainfall for this period based on 6 minute pluviograph data is 745mm.

6.4.2 Source Nodes

The source nodes represent the catchment areas within the development modelled in MUSIC. The model incorporates multiple sub-catchment source nodes representing various land uses (i.e. residential, park, neighbourhood centre etc). The lumped catchment methodology outlined within the *MUSIC Modelling Guidelines* (2010) has been adopted for this master planning analyses.

Rainfall runoff and pollutant export parameters were assigned for the different land use areas in accordance with *Table 3.7* and *Table 3.8* of the *MUSIC Modelling Guidelines* (2010).

Fraction impervious assumptions have been made, generally in accordance with *Table 3.5* of the *MUSIC Modelling Guidelines* (2010) as per **Table 6.3** below.

Table 6.3 MUSIC Fraction Impervious Assumptions

Land Type / Density	Road	Roof	Ground
25 dwellings / ha*	70%	100%	24%
40 dwellings / ha	70%	100%	30%
School	75%	100%	60%
Commercial	75%	100%	60%

*Note fraction impervious values were interpolated based on *Table 3.5* of the *MUSIC Modelling Guidelines* (2010)

***Table 6.3** was added to address Item 7 of the Queensland Government's Further Issue letter dated February 2018*

Catchment breakdown into Road, Roof and Ground nodes was determined based on typical breakdown outlined in the *MUSIC Modelling Guidelines* (2010) as per **Table 6.4** below.

Table 6.4 MUSIC Breakdown

Land Type / Density	Road	Roof	Ground
25 dwellings / ha	27%	33%	40%
40 dwellings / ha	30%	35%	35%
School	26%	33%	41%
Commercial	30%	50%	20%

The source node parameters presented in **Table 6.5** were implemented in MUSIC modelling. Refer to **Appendix G** for MUSIC model layout and a breakdown of different land use areas. It is noted that only the development footprint areas (including parks and sports fields) have been included in the MUSIC analyses. Undeveloped areas, particularly those adjacent to the river and the floodplain have been excluded from the MUSIC analysis. Refer to Drawing No. **16-003350-SK205** in **Appendix H** for the MUSIC catchment delineation.

Table 6.5 MUSIC Source Nodes

MUSIC Catchment	Total Area (ha)	Landuse
F 25dw	30.57	Urban Res
M 40dw	6.44	Urban Res
M Commercial	13.20	Commercial
N Commercial	16.70	Commercial
O Commercial	3.44	Commercial
O School	7.03	Urban Res
R 25dw	18.30	Urban Res
U 25dw ROL1	12.72	Urban Res
U 40dw ROL1	3.87	Urban Res
U 25dw Exc ROL1	49.72	Urban Res
U 40dw Exc ROL1	38.3	Urban Res
W 25dw	1.85	Urban Res
Channel Sections	13.28	Channel
Total	215.42	

6.4.3 Drainage Links

Default drainage link settings have been adopted for the model. As stated in *Section 4.17* of *MUSIC Modelling Guidelines* (2010), MUSIC's default settings apply a conservative approach in assessing treatment performance, assuming all flows and pollutants from the catchment arrive at the treatment node at the same time. Flow routing has not been incorporated in accordance with *Section 4.17* of *MUSIC Modelling Guidelines* (2010).

6.4.4 Treatment Nodes

Bioretention Treatment

Bioretention treatment was modelled with the filter areas presented in **Table 6.6**. During detailed design, pre-treatment in accordance with *Table 13* of the *Bioretention Technical Design Guidelines* (2014) will be provided in addition to the filter areas specified.

Bioretention filter areas presented below are to be proportionally split into multiple basins within the catchments. This will be investigated further during subsequent ROL applications.

Table 6.6 Bioretention Filter Areas – SWQ Precinct A only

MUSIC Catchment	Bioretention Filter Area (m²)	Bioretention Surface Area (m²)
F	1,750	2,502
M & N	3100	4,433
O	750	1,072
R	1,000	1,430
U_ROL1	1,100	1,501
U	5,500	7,865

Bioretention filter areas to be split into multiple cells no greater than 800m²

> *This table has been updated to present the amendments to the MUSIC Model. The surface area of each basin (incorporating batters and extended detention depths) were modelled for a more accurate representation of the treatment provided by the basins.*

The following parameters were also applied consistently across all bioretention nodes:

- 500mm filter media depth;
- 300mm ponding extended detention depth;
- Overflow weirs were modelled as 10% of the filter area;
- 30mg/kg filter media Orthophosphate content;
- 400mg/kg filter media TN content; and
- 200mm/hr filter media saturated hydraulic conductivity.

The Orthophosphate and TN content in the filter media were adopted from Healthy Waterways *http://healthywaterways.org/initiatives/waterbydesign/stormwater* (accessed February 2016).

For catchments M & N, and O, the bioretention filter areas can be incorporated at the base of the detention basins (refer to **Section 4.3.1**). Bioretention filter areas must be split into multiple cells no greater than 800m² in accordance with the *Bioretention Technical Design Guidelines* (2014).

Rainwater Tanks

Rainwater tanks are only proposed for medium density (25 dwelling /ha) and commercial areas for Catchment M, N and O within SWQ Precinct A. Hence, rainwater tanks are not proposed for ROL Stage 1 (which is the development of Catchment R, portion of U and O). As per the master plan strategy rainwater tanks are not proposed for other areas of the overall master plan area. Rainwater tanks for the north areas are provided as part of the total water cycle management strategy and to reduce frequent flows discharging towards Teviot Road (to reduce the 'sogginess' of this area). **Table 6.7** presents the rainwater tank parameters modelled in MUSIC.

The following assumptions were used for modelling rainwater tanks:

- Rainwater tank volumes for neighbourhood centres and the school were estimated assuming 1.5kL per 50m² of roof.
- Rainwater tank volume for medium density residential (25 dwellings/ha) areas was estimated based on 3kL per dwelling.
- 50% of neighbourhood centre is roof.
- 33.5% of medium density residential (25 dwellings/ha) areas are roof.
- 50% of all roof areas connected to rainwater tanks.
- The commercial rainwater tanks modelled using the parameters of 5kL round tanks, the medium density residential rainwater tanks modelled using the parameters of 3kL round tanks, and the school rainwater tanks modelled using the parameters of 50kL tanks.
- Toilet flushing re-use for residential areas have been calculated based on the *MUSIC Modelling Guidelines* (2010). Refer to **Appendix G** for the re-use estimation.
- Toilet flushing re-use for commercial areas and the school have been estimated as 25% of the total water demand. Refer to Water and Wastewater Infrastructure Master Plan (Report No. **B13343.W-03**) for the total water demand estimations. Refer to **Appendix G** for the re-use estimation.
- Some roof water re-use for irrigation within the school area is required for meeting the flow frequency requirements (**Section 8**). Therefore it is proposed to irrigate a minimum of 0.21ha of the school landscaped area with harvested roof water. This has been included in MUSIC.

Table 6.7 Rainwater Tank Parameters

Parameter	**Catchment M**		**Catchment C**		**Catchment O**
	Neighbourhood Centres	Medium Density Res.	Neighbourhood Centres	Medium Density Res.	School
No. of Tanks Modelled	100 x 5kL	200 x 3kL	120 x 5kL	166 x 3kL	10 x 50kL
Total Rainwater Tank Volume (kL)	500	600	600	498	500
Depth above Overflow (m)	0.12	0.14	0.18	0.14	0.39
Total Surface Area (m²)	330	380	396	315.4	152
Initial Volume (kL)	200	600	600	498	500

Overflow Pipe Diameter (mm)	569	1,273	986	1,160	285
Irrigation Demand (kL/year)	-	-	-	-	791
Internal Re-Use (kL/day)	3.36	6.80	8.94	6.31	6.08

During future ROL of the Catchments M, N and O, rainwater tank parameters may be amended to provide community storage rather than individual devices.

6.5 SWQ Precinct A MUSIC Model Results

This section has been updated to address Item 7 of the Queensland Government's Further Issue letter dated February 2018. **Table 6.8** *presented the updated Precinct A MUSIC model results.*

Since removal of wetland has resulted in a slight shortfall in pollutant reduction of TSS, an investigation to pursue living waterways objectives has been undertaken for three separate stormwater precincts (SWQ Precinct A, B and C) over the master plan area. The MUSIC modelling results for SWQ Precinct A only is indicated in **Table 6.8** below.

Table 6.8 MUSIC Results – SW Precinct A Results

Pollutant	Source Load (kg/year)	Residual Load (kg/year)	Load Reduction Achieved	WQO Achieved?
Total Suspended Solids (kg/yr)	160,000	29,600	82%	Yes
Total Phosphorus (kg/yr)	333	90	73%	Yes
Total Nitrogen (kg/yr)	2,110	1,040	51%	Yes
Gross Pollutants (kg/yr)	25,500	481	98%	Yes

Table 6.8 *has been updated as part of the Issue C report updates.*

As demonstrated in ***Table 6.8*** *above, the Precinct A achieved the WQO's as required under the SPP (2017). Furthermore, the Living Waterways objectives and measures is summarised in Living Waterways table in* ***Appendix E****, which indicates that a 1 drop rating will be achieved for SW Precinct A.*

6.6 ROL Stage 1 Treatment Strategy

Since only a portion of SWQ Precinct A will be developed during ROL Stage 1 (i.e. Catchment R, part of Catchment U and Catchment O will be developed), the following section indicates the treatment strategy required for ROL Stage 1 development only.

The initial treatment strategy proposed for ROL Stage 1 is listed below and summarised in **Figure 6.1**.

- *Bioretention Basin U¬_ROL1* (filter area: 1,100m2) – It is proposed to construct Catchment U_ROL1 bioretention basins as per the SWQ Precinct A strategy to treat all areas developed during ROL Stage 1 within this catchment. This incorporates a small area of bypass for discharges to State Land.
- *Bioretention Basin R* (filter area: 1,000m2) – It is proposed to construct Catchment R bioretention basins as per the SWQ Precinct A strategy to treat all areas developed during ROL Stage 1 within this catchment.
- *Partial Construction of Bioretention Basin O* (filter area: 165m2) – during ROL Stage 1 only 22% of the catchment is developed (i.e. entrance road and park area). As such, it is proposed only a portion of the Bioretention Basin O is proposed to be constructed during ROL Stage 1 development.
- *Temporary Bypass of Catchment M & N* – during ROL Stage 1 only 1.2% of the Catchment M and N will be developed. As such, it is proposed to temporarily bypass runoff from these areas. Runoff from this small area will be discharged to temporary swales or sediment control measures that will provide some capture of suspended solids.

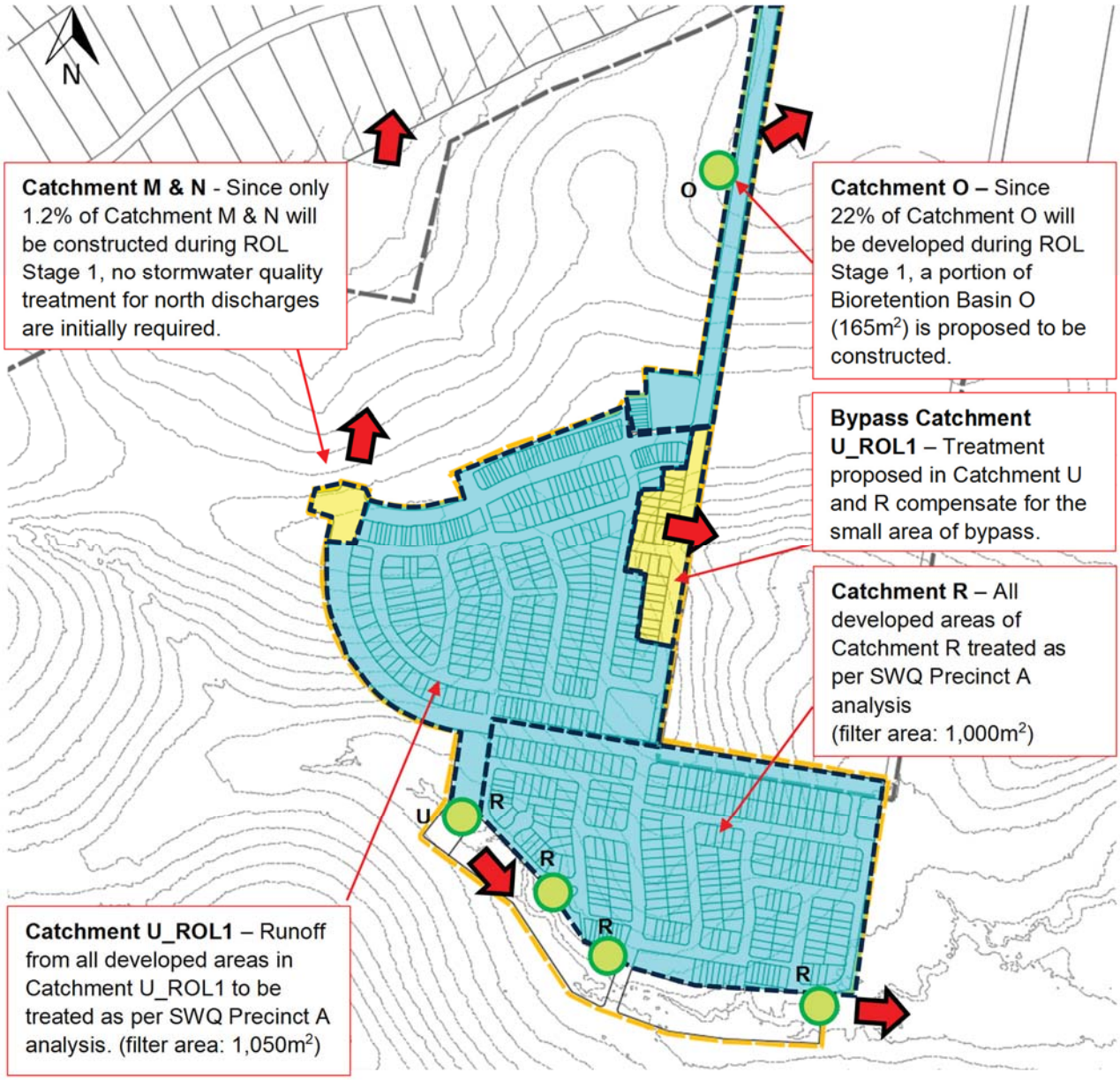

Figure 6.1 ROL Stage 1 Stormwater Quality Management Strategy

Further details are provided on Drawing No. **16-003350-SK205** in **Appendix H**

6.6.1 ROL 1 MUSIC Model Results

This section has been added to the Issue C report to address Item 7 of the Queensland Government's Further Issue letter dated February 2018.

***Table 6.9** below presents the MUSIC modelling results for the ROL 1 site only.*

Table 6.9 MUSIC Results – ROL 1

Pollutant	Source Load (kg/year)	Residual Load (kg/year)	Load Reduction Achieved	WQO Achieved?
Total Suspended Solids (kg/yr)	25,400	5,280	79%	No
Total Phosphorus (kg/yr)	50.8	14.7	71%	Yes
Total Nitrogen (kg/yr)	305	160	48%	Yes
Gross Pollutants (kg/yr)	4,110	228	94%	Yes

***Table 6.9** has been added as part of the Issue C report amendments.*

*As demonstrated in the above table, pollutant reductions meet and exceed WQO's for TP, TN and GP with a slight shortfall of TSS by 1%. The lower pollutant removal is a result of Catchment W bypassing quality treatment (due to topographical constraints). As detailed in **Table 6.8** above, these slight shortfalls are addressed with the construction of the surrounding Precinct A.*

7 Construction, Operational Management & Maintenance Of SQIDS

The following sections discuss the inspection and maintenance details of the SQIDs proposed for ROL Stage 1. **Appendix F** outlines the frequency and procedures for the maintenance inspections of the Bioretention devices. General requirements, health and safety and yearly reviews for the SQIDs are outlined in **Section 7.2**.

No monitoring of water quality is proposed. The level of operational management and the maintenance proposed is considered best practice and if followed will ensure SQIDs will operate to their design intent.

7.1 Bioretention Devices

Outlined below are the proposed procedures and methodology for the construction and operational management as well as the maintenance of the Bioretention devices proposed as part of the development. The following methodology will be followed through the construction, establishment and operational phases of the Bioretention devices. Details provided in this section will be incorporated into the detailed design of the development.

7.1.1 Construction & Establishment Phases

Construction of the development and the building works has the potential to mobilise large quantities of sediment in runoff. For the Bioretention devices to perform as designed there is a need to protect filter media and basin vegetation during this phase of the development. Therefore a staged construction and establishment method for construction of the Bioretention devices will be followed.

It is proposed to follow an installation procedure for the Bioretention devices generally in accordance with *Option 1* of the *Staged Construction and Establishment Methodology* as outlined in *Table 3.6* and *Section 3.8.1* of the Water by Design *Construction and Establishment Guidelines* (2011). A summary of this methodology is presented below.

1. Civil Works (Functional Installation) – Initially the Bioretention devices will be used as a Sediment Basin. Once the majority of the civil construction works are complete, earthworks and shaping to create the layout and functional elements of the Bioretention devices will be undertaken. The installation of functional elements (e.g. inlets, outlets structures, subsoil drainage, transition layers and filter media) shall be undertaken as per the methodology detailed in *Section 3.9.1* in the Water by Design *Construction and Establishment Guidelines* (2011). Prior to the commencement of the Building Phase, sediment fences will be erected around the perimeter of the basins to avoid the entry of sediment. Laying a temporary filter cloth (or 25mm thick layer of course sand and 25mm of topsoil) over the filter surface shall protect the Bioretention devices during both the Civil Works and the Building Phase.

2. Building Phase (Building Construction) – During this phase the Bioretention devices shall continue operate as Temporary Sediment Basin. Sediment fences shall remain around the perimeter of the basin (both around the filter media and the top of batter) to restrict sediment inflow. Clear indications of the restriction of traffic to the Bioretention systems shall also be displayed.

3. Landscape Establishment (Operational Establishment) – when the Building Phase is 80% complete, the temporary protective measures and accumulated sediments within the basin will be removed. The basins shall be planted with vegetation and landscaping as proposed. Sufficient watering and removal of weeds following planting shall be undertaken in accordance with *Section 3.9.3* of the Water by Design *Construction and Establishment Guidelines* (2011).

7.1.2 Operational Phase

During Operational Phase, regular inspections of the Bioretention devices is required to ensure vegetation establishes and the properties of the filter media remain effective.

- **Inspection Requirements**

Checklists have been developed for the Bioretention devices. The condition and maintenance carried out will be recorded on the checklist at the time the inspection and/or maintenance is undertaken. A copy of the checklist is presented in **Appendix F**.

Maintenance personnel should also be encouraged to report and document changes in vegetation type within the Bioretention devices. Photographic documentation and mapping of vegetation types are to be recorded annually to determine changes in vegetation over time. Photographs of the device are to be taken at the same location annually.

Through these procedures a reliable maintenance database can be developed and used to determine if the maintenance undertaken is ensuring the SQID is functioning as intended.

Except for periods of extended wet weather, mosquitoes are unlikely to be an issue as surface water within the Bioretention devices are not expected to remain for more than two days.

- **Weed Removal**

Maintenance personnel will need to identify species of both terrestrial and semi-aquatic weeds common to the area. As the Bioretention devices are “dry” SQIDs, aquatic weed infestation is unlikely. When weeds have been identified they are to be removed by hand immediately or eradication methods scheduled before the infestation becomes larger and more difficult to control. It should be noted that herbicides should not be used in the removal of invasive weeds as this has negative impacts on downstream water quality.

- **Replanting**

Replanting of vegetation is to be carried out to replace dead or damaged vegetation, vegetation that has been removed by scour or erosion, or vegetation that is being re-planted following tilling or the replacement of filter media. Removed vegetation should be replaced by plants of similar size and species, or as indicated on the appropriate Landscaping Plans.

- **Filter Inspection and Replacement**

Fine sediment and silt may accumulate within the filter media of the Bioretention devices over time. Removal of sediment and silt trapped within the filter media is expected to be the most costly maintenance requirement for Bioretention devices.

It is recommended that a visual inspection of the infiltration properties be undertaken at least three times per year with more frequent inspections no greater than three months apart between October and May. This is to determine whether built-up fine sediment and silt has reached a point where the filter media has become clogged.

The infiltration properties of the filter media within the Bioretention devices needs to be checked after a period of significant rainfall event, which is defined as a 24 hour period with rainfall greater than 100mm, or a shorter period with an average rainfall intensity greater than 50mm/hr. This is an ideal period to assess the infiltration properties as water should not pond for an extended period. Therefore inspections should occur 24 to 72 hours after an appropriate rainfall event.

In the event that isolated boggy patches occur within the Bioretention devices then the subsoil drainage pipes could be blocked. If this is not the case and no other blockages have been observed then surface of the media is to be tilled (raked and aerated) to a depth of 100 to 150mm. This will require temporarily removing and storing the surface vegetation prior to tilling the surface. Should the infiltration properties be improved then the removed vegetation and coarse aggregate layer can be replanted. Should tilling prove unsuccessful or if an infiltration check indicates filter media to be clogged, then the top portion of the filter media is to be replaced as follows:

1. Removal of surface vegetation and coarse aggregate layer and store for re-establishment;

2. Remove the top 150mm of filter media and dispose of in an approved manner;

3. Till the remaining filter media to a further depth of 300mm;

4. Place a new layer of appropriate filter media as per the specification (refer to **Appendix F**), free from organic matter, clay and silt; and

5. Replant the removed vegetation.

If blockages occur frequently, a filter media with a higher saturated hydraulic conductivity should be considered. Reassessing the species and planting density of vegetation is also an option. Unless changes to the filter media specification are made through a review of the SQID performance, the filter media to be used for the Bioretention devices is to be a Sandy Loam as per the FAWB Guidelines for Filter Media in Biofiltration Systems (Version 3.01, 2009) presented in **Appendix F**.

- **Subsoil Drainage Inspection & Cleanout**

The build-up of fine sediment and silt within the subsoil drainage pipes is unlikely as it will be trapped by the filter media. However the subsoil drainage is to be checked annually for blockages that may be caused by foreign matter entering through cleanout inspection openings or by small fauna. This can be done by either:

- Observing the condition of the subsoil drain through the cleanout and inspection openings located towards the downstream end of a subsoil drainage pipe.
- Observing the amount of sediment and silt flushed into the downstream field inlet when water is pumped into the upstream end of the subsoil drainage line (through a cleanout and inspection opening).

If a considerable amount of sediment and silt is observed or carried into the downstream inlet, then each subsoil drainage line must be flushed out with high pressure water.

Water is to be pumped into each subsoil drainage pipe through the upstream cleanout inspection opening until all sediment has been ejected from the pipe. To collect the water and ejected sediment within the downstream pit a temporary barrier is to be placed over the downstream pipe opening (such as sand bags) and a pump used to draw the water, sediment and silt out of the pit and irrigated onto areas of open space away from each basin. This will ensure the sediment and silt does not enter the downstream waterway.

If frequent issues occur with the subsoil drainage system, CCTV checking could be undertaken to identify any damage subsoil drainage.

- **Monitoring**

Visual monitoring of Bioretention devices is proposed as part of the inspection and maintenance requirements for the devices. Visual inspections will occur at least three times per year with more frequent inspections to occur no more than three months apart between October and May. Inspection should be made not less than 24 hours and not more than 72 hours after the cessation of rainfall if the total rainfall on any day exceeds 100mm.

7.2 General Requirements

7.2.1 Yearly Review of Maintenance Management Plan

Each year a review is to be carried out to determine if the programmed inspection and maintenance (including checklists) is ensuring SQIDs are functioning as intended. The review should include an assessment of the maintenance database to determine whether the programmed inspections and maintenance is effective. Information on the database should be assessed to determine whether any noticeable changes are evident in vegetation, presence of fauna and operational efficiency of any structures or features of the device. This will further provide indicators as to whether sufficient information is being recorded for management purposes.

7.2.2 Maintenance Personnel Safety (Oh&S)

The Workplace Safety Regulation 2011 requires that all reasonably practicable steps be taken to protect an employee's health in a workplace. Organisations involved in the inspection and maintenance of the SQIDs should therefore:

- Have a documented occupational health and safety policy in place;
- Ensure all staff and maintenance personnel are aware of and abide by the policy; and
- The policy provides a mechanism for review and improvement.

As part of the policy personnel involved in the maintenance of the SQIDs are to have sufficient resources (such as personnel protective equipment, training etc.) to carry out the task in a safe manner.

7.2.3 General Public Safety

The safety of the general public in the area of the SQID being maintained also needs to be ensured. Notices to inform the staff and public accessing the site regarding the SQID maintenance needs to be circulated prior to the scheduled date. Temporary signage and safety barriers need to be erected around maintenance work areas prior to the works commencing and are not to be removed until all works have finished.

8 Conclusion & Recommendations

Calibre Professional Services Pty Ltd has been commissioned by Celestino Pty Ltd to prepare a *Concept Stormwater Management Plan* in support of the initial Reconfiguring of Lot (*ROL*) application for Stage 1 of the Riverside development in Jimboomba. This report demonstrates that the stormwater and flood management strategies adopted for ROL Stage 1 development, are generally in accordance with the master planning strategies and comply with the Queensland Governments Department of Infrastructure Local Government and Planning (*DILGP*) guidelines, State Planning Policy (2017), Logan City Council's Planning Scheme (2015) and all relevant best practice guidelines and standards.

> *This Issue (C) of the report has been updated to address the stormwater items of the Queensland Government Department of State Development, Manufacturing, Infrastructure and Planning's Further Issues for PDA Development Application (Ref: DEV2017/901, dated 19/02/18).*

The outcomes of this report are as follows, the outcomes following the Issue C amendment have been highlighted with Italicised indented text below:

- *Stormwater Management (Quantity)* – Hydrological analysis using XP-RAFTS has determined the change in peak flows at each discharge location from the site as a result of the ROL Stage 1 development. The peak flow management strategy (summarised on **Figure 3.1**) incorporates a catchment diversion and partial construction of the detention basin on the future School Site. For discharges to the north of Teviot Road, XP-RAFTS analysis demonstrates a 1% to 3% reduction in peak flows. For discharges to the west-east drainage path, previous (master plan) analysis demonstrates no adverse impact over the Logan River. For north east discharges to State Land on Lot 71 SL8963, analysis indicates up to a 5% reduction in peak flows. For south east discharges to the State Land on Lot 71 SL8963 a slight increase in peak flows (up to 192L/s) has been determined, however this equates to only a 10mm difference in 1% AEP flood levels and 0.1m/s increase in velocities (with a maximum velocity lower than 1m/s), which is not considered to be perceivable, let alone adverse. Overall stormwater quantity management investigations demonstrate no adverse impact at each discharge location. Refer to **Section 3** of this report.

- *Waterway Stability Management* – Hydrological analysis presented in **Section 3** demonstrates no adverse impact for the 63% AEP storm for discharges to the north of Teviot Road and to Lot 71 (for south east and north east discharges). Additional hydrological analysis using XP-RAFTS was undertaken to assess the change in peak flows along the west-east drainage path (south of ROL Stage 1). Results indicate a reduction in peak flows (by 1% to 2%) downstream of ROL Stage 1 within the west-east drainage path. The online waterway stability detention basin proposed in the master plan analysis is not required for the interim ROL Stage 1 development. Refer to **Section 4** of this report for further details.

  The minor model updates have demonstrated the ROL 1 site achieves a reduction in peak flows of up to 5% downstream within the west-east drainage path. Thus the online waterway stability detention basin proposed in the master plan analysis is not required for the interim ROL Stage 1 development.

- *Local Flooding* – As a portion of the main west-east drainage path running through the master plan area will be constructed in ROL Stage 1. Refined XP-RAFTS and HEC-RAS modelling was undertaken to provide an adequate channel design under interim ROL Stage 1 and fully developed master plan conditions. Appropriate flood immunity levels were determined in the local flooding investigations. Refer to Section 5 of this report.

- *Stormwater Management (Quality) & Total Water Cycle Management* – A stormwater quality management and total water cycle management strategy utilising bioretention basins, rainwater harvesting, wetlands, water features and vegetated swales was proposed as part of the master plan investigations. Since the master plan analysis, the proposed semi offline wetland for Catchment U has been removed from the strategy. Updated MUSIC Modelling (excluding the wetland) indicates that this results in a slight shortfall (by 4%) in pollutant reduction for Total Suspended Solids (TSS) with reduction targets for other pollutants met and/or exceeded. In order to compensate the slight shortfall in TSS, the Living Waterways framework has been adopted to provide an alternative solution for achieving the performance outcomes of *SPP (2017) Water Quality*.

  The Precinct A MUSIC model was updated to incorporate the bioretention basin surface areas with factoring the extended detention depth and batters. The updated MUSIC modelling demonstrates Precinct A achieves the WQO's as required under the SPP (2017).

  Living waterways is an innovative approach which integrates stormwater features into environmental, educational, community and economic benefits. For the Living waterways analysis, the master plan was divided into three Stormwater Quality Precincts (SWQ Precinct A, B and C). Using the framework a drop rating of 1 has been demonstrated for the first SWQ Precinct A (which incorporates ROL Stage 1). Based on this, the performance outcomes of the *SPP* (2017), required under *DILGP* guidelines, will be achieved and the proposed stormwater management strategy is considered to be appropriate. Details for the treatment measures required during ROL Stage 1 have been provided. Refer to Section 6 of this report.

- *Construction, Operational Management & Maintenance of SQIDs* – Details for construction, operational management and maintenance of stormwater quality improvement devices (SQIDs) is detailed in Section 7.

Based on the above outcomes, it is recommended that the proposed stormwater strategies for ROL Stage 1 development be approved and adopted in detailed design. Future design may result in changes to the concepts, however the design objectives are to be maintained.

9 References

- Department of Energy and Water Supply (2017), *Queensland Urban Drainage Manual*.
- Department of State Development, Infrastructure and Planning (2017), *State Planning Policy*.
- Healthy Waterways (2010), *MUSIC Modelling Guidelines Version 1.0.*
- Healthy Waterways (2010), *Water Sensitive Urban Design Technical Design Guidelines.*
- Institution of Engineers, Australia (1987), *Australian Rainfall and Runoff.*
- *Greater Flagstone Urban Development Area Development Scheme dated October 2011;*
- EDQ (May 2015) *Guideline 12 Park Planning.*
- EDQ (May 2015) *Guideline 13 Engineering Standards*.
- EDQ (May 2015) *Guideline 14 Environmental Values & Sustainable Resource Use.*
- EDQ (May 2015) *Guideline 15 Protection from Flood and Storm.*
- SEQ Water (June 2012) *Development Guidelines.*

10 Disclaimer

This report has been prepared on behalf of and for the exclusive use of Celestino Pty Ltd and is subject to and issued in accordance with the agreement between Calibre Professional Services Pty Ltd.

Our investigation and analysis has been specifically catered for the particular requirements of Celestino Pty Ltd and may not be applicable beyond this scope. For this reason, any other third parties are not authorised to utilise this report without further input and advice from Calibre Professional Services Pty Ltd.

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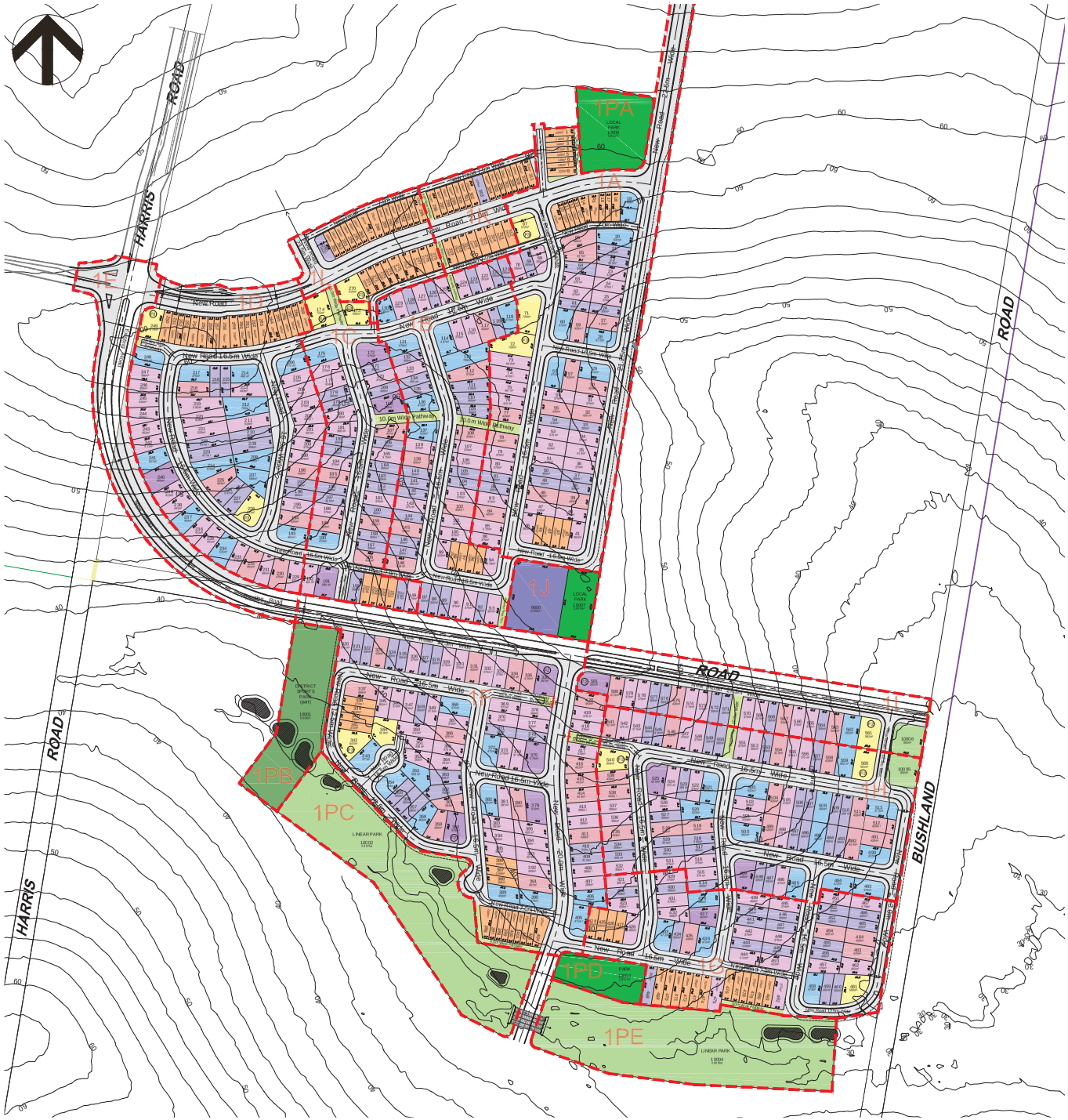
The investigation and analysis has relied on information provided by others. We accept no responsibility for accuracy of material supplied by others. The accuracy of the investigation, analysis and report is dependent upon the accuracy of this information

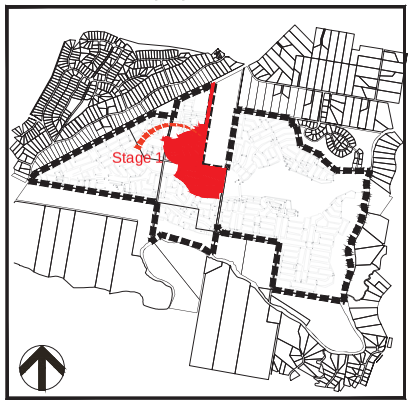
ROL1 – RIVERSIDE, JIMBOOMBA

Appendix A Layout

CELESTINO PTY LTD



CONTEXT PLAN (nts)



LEGEND
Stage Boundary
New Road
Special Use Allotment
Local Park
Linear Park
District Sports Park
Pathway
Multi-Family Lot and maximum number of dwellings (F2)

DEVELOPMENT SUMMARY		
Terrace/Terrace with Loft (<10.0m)	129	22.2%
Villa/Villa with Loft (10.0m-12.49m)	132	22.7%
Premium Villa (12.5m-13.99m)	170	29.2%
Premium Villa (14.0m-14.99m)	69	11.9%
Courtyard (15.0m-17.99m)	55	9.5%
Courtyard Premium (18.0m-19.99m)	9	1.5%
Traditional (=>20.0m)	3	0.5%
Potential Multi-Family (F2)	14	2.4%
Special Use	1	0.2%
Total Number of Lots	582	100%

Teviot Road, Jimboomba

For

Riverside | CELESTINO

IMPORTANT NOTES:
(These notes are an integral part of this plan)

This plan was prepared to support a Reconfiguration of Lot application for the land situated at Jimboomba. The Contours, boundaries, creek line, flood lines, building locations have all been scaled and should not have any reliance based on them as they are only intended as a general guide. The configuration of allotments shown on this plan is subject to Local Authority (and relevant State Government Authority) approvals, detailed design, final survey, and registration of survey plans. Any comments contained on this plan should be confirmed by the relevant authorities. The dimensions, areas and total number of lots shown hereon are subject to field survey and also to the requirements of Council and any other authority which may have requirements under any relevant legislation. In particular, no relevance should be placed on the information on this plan for any financial dealings involving the land.

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Data Sources

Cadastral Boundaries	30697-GP10-A
Contours / Topographic	DNR&M Lidar supplied data
Flood Level	Logan City Council shp file
Engineering Design	Calibre Consulting

Issue	Revisions	Date	Drawn
B	Add 2x mid-block pathways / orientate lots / add 10.0m lot / add LATM / new intersection / Bus Stop	14.11.2018	KS
A	Original	07.12.2017	KS/PS

Locality:	Jimboomba
Local Authority:	Logan City Council
Horizontal Meridian:	MGA
Vertical Level Datum:	AHD (Lidar)
Scale:	1:4,000@A3
Designed:	PS/KS
Drawn:	KS
Checked:	KS
Plot Date:	30 Jan, 2019
Computer File Ref:	30697-GP10-B (sheets 1 & 2).dwg

Plan of Subdivision Stage 1

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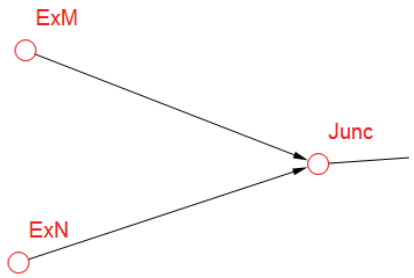
Drawing No: 30697-GP10 (sheet 1 of 3)
Issue: B

ROL1 – RIVERSIDE, JIMBOOMBA

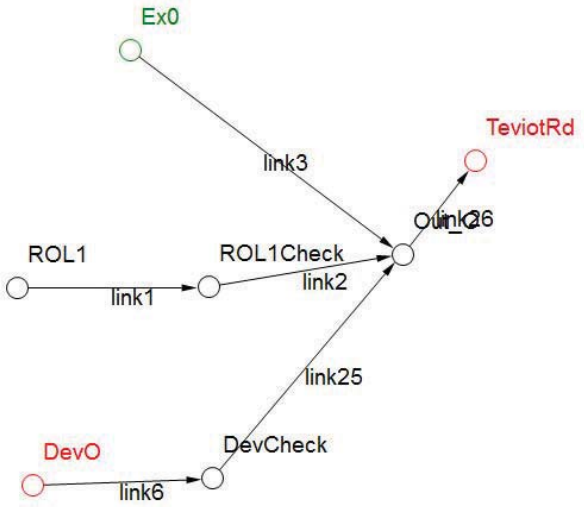
Appendix B XP-RAFTS Modelling Information

CELESTINO PTY LTD

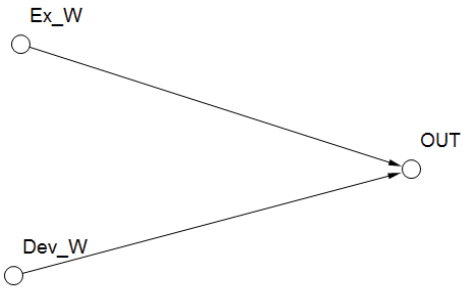
XP-RAFTS Existing & ROL Stage 1 Scenario Model Configuration – Discharge North of Teviot Road



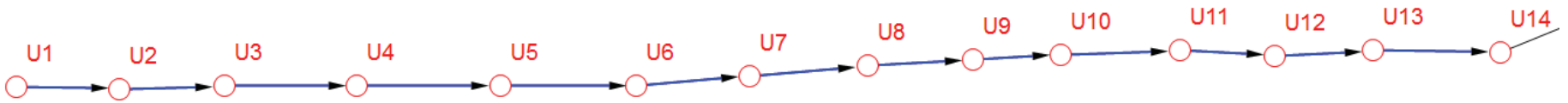
XP-RAFTS Existing & ROL Stage 1 Scenario Model Configuration – North East Discharge to State Land (Lot 71 SL8963)



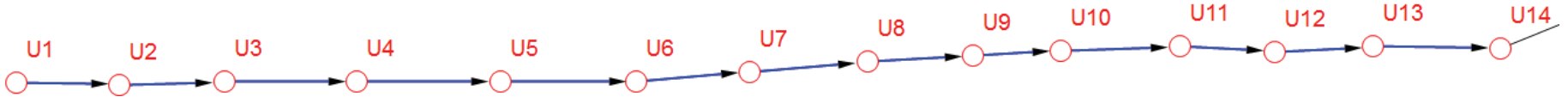
XP-RAFTS Existing & ROL Stage 1 Scenario Model Configuration – South East Discharge to State Land (Lot 71 SL8963)



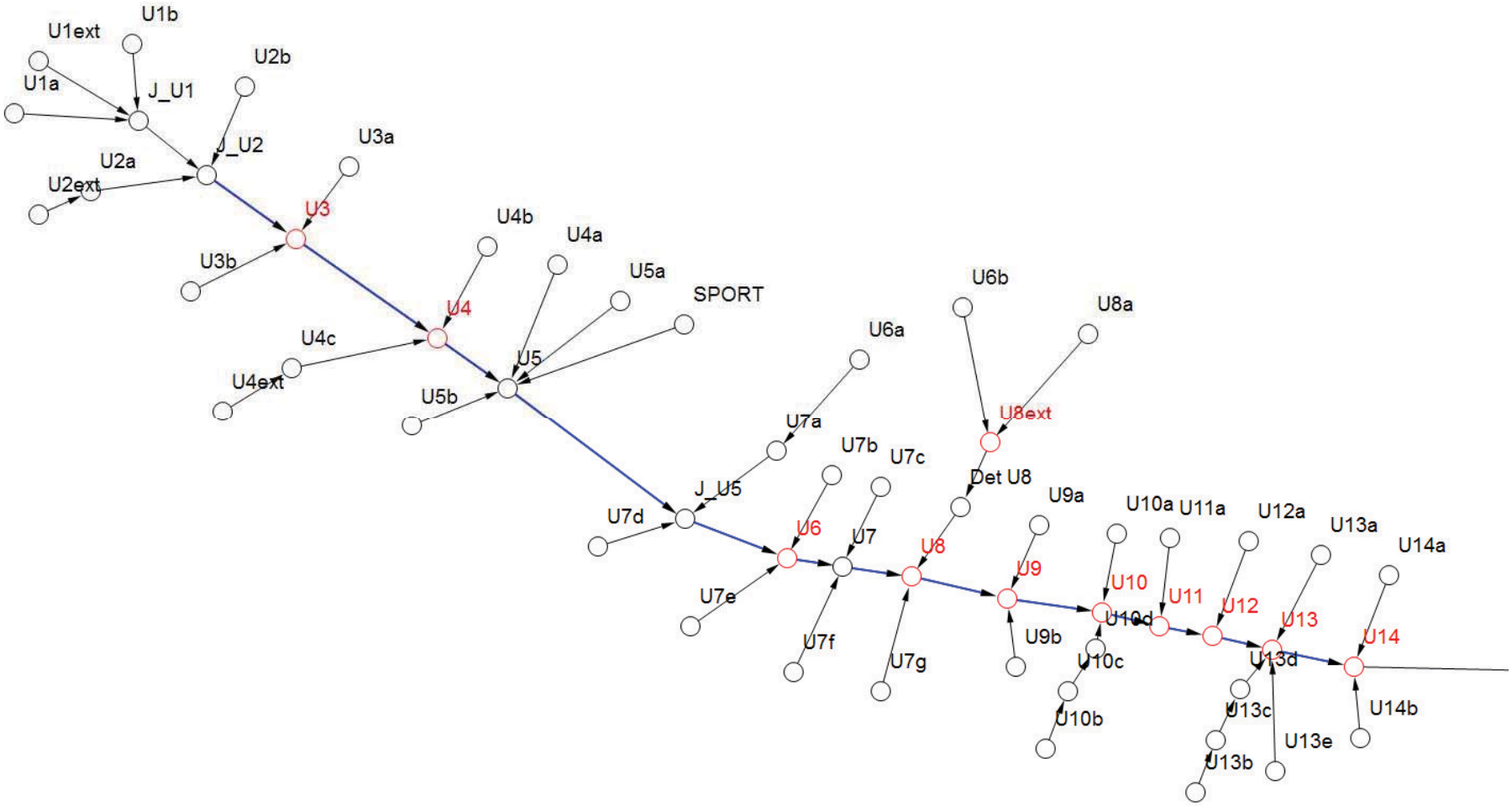
XP-RAFTS Existing Scenario Model Configuration – Main Watercourse



XP-RAFTS ROL Stage 1 Developed Scenario Model Configuration – Main Watercourse



XP-RAFTS Fully Developed Scenario Model Configuration – Main Watercourse



ROL1 – RIVERSIDE, JIMBOOMBA

Appendix C Manning's Calculations

CELESTINO PTY LTD

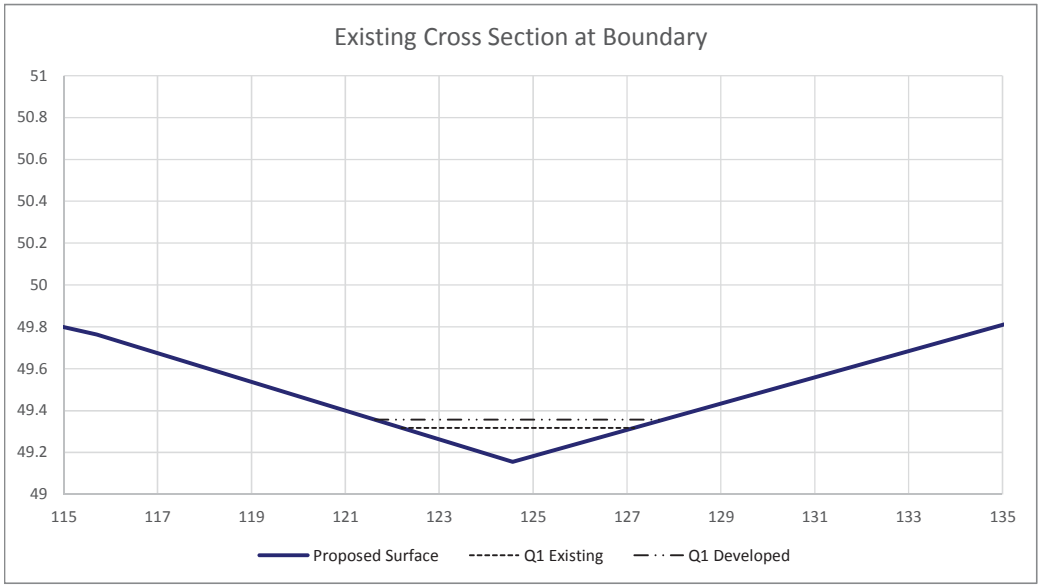
MANNING'S WATER SURFACE EXTENT CALCULATION - 63% AEP

Filename: \\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\9_Technical\Calculations\Comparisor
Date: 8/12/2017
By: GB

Manning's calculation as per Equation 4.2.3 of Australian Rainfall and Runoff (1987)

SECTION

CROSS SECTION DETAILS				Q1 Existing			Q1 Developed		
POINT	CH	Z	n	wA	wP	n x wA	wA	wP	n x wA
1	0	58.555	0.060						
2	22.826	57	0.060						
3	56.384	54	0.060						
4	76.375	52	0.060						
5	90.133	51.091	0.060						
6	102.355	50.436	0.060						
7	115.702	49.763	0.060						
8	124.566	49.155	0.060	0.19	2.38	0.01	0.30	2.94	0.02
9	153.982	51	0.060	0.21	2.60	0.01	0.32	3.22	0.02
10	168.843	52.119	0.060						
11	177.438	52.483	0.060						
12	183.251	52.921	0.060						
13	198.203	53	0.060						
14	208.974	53.362	0.060						
15	246.857	54.36	0.060						
16	279.612	55.453	0.060						
17	298.59	55.873	0.060						
18	313.498	55.984	0.060						
20	332.574	55.889	0.060						
21	344.832	55.632	0.060						
22	359.512	55.724	0.060						
				wA	wP	n x wA	wA	wP	n x wA
			TOTAL	0.40383	4.975734	0.02423	0.619513	6.162869	0.037171
	S								
	0.0359			R	n	Q	R	n	Q
				0.08116	0.060	0.24	0.100523	0.060	0.42
				Q1	0.24		Q1	0.42	
	45.971		WSL		49.318			49.35648	
	Calculated by Manning's Equation				0.24			0.42	
			Vel (m/s)		0.59			0.68	0.09



MANNING'S WATER SURFACE EXTENT CALCULATION - 5% AEP

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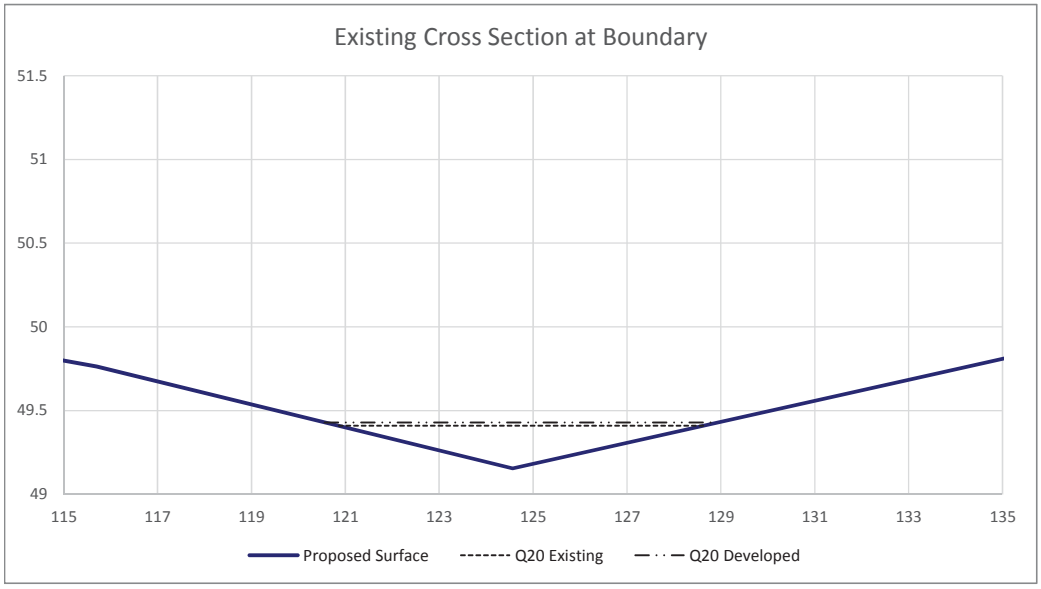
Date: 8/12/2017
By: GB

Manning's calculation as per Equation 4.2.3 of Australian Rainfall and Runoff (1987)

SECTION

CROSS SECTION DETAILS				Q20 Existing			Q20 Developed		
POINT	CH	Z	n	wA	wP	n x wA	wA	wP	n x wA
1	0	58.555	0.060						
2	22.826	57	0.060						
3	56.384	54	0.060						
4	76.375	52	0.060						
5	90.133	51.091	0.060						
6	102.355	50.436	0.060						
7	115.702	49.763	0.060						
8	124.566	49.155	0.060	0.47	3.72	0.03	0.55	4.01	0.03
9	153.982	51	0.060	0.52	4.06	0.03	0.60	4.39	0.04
10	168.843	52.119	0.060						
11	177.438	52.483	0.060						
12	183.251	52.921	0.060						
13	198.203	53	0.060						
14	208.974	53.362	0.060						
15	246.857	54.36	0.060						
16	279.612	55.453	0.060						
17	298.59	55.873	0.060						
18	313.498	55.984	0.060						
20	332.574	55.889	0.060						
21	344.832	55.632	0.060						
22	359.512	55.724	0.060						
				wA	wP	n x wA	wA	wP	n x wA
			TOTAL	0.987011	7.778909	0.059221	1.150974	8.400218	0.069058
	S								
	0.0359			R	n	Q	R	n	Q
				0.126883	0.060	0.79	0.137017	0.060	0.97
				Q20	0.79		Q20	0.97	
	45.971		WSL		49.409			49.42962	
			Calculated by Manning's Equation		0.79			0.97	
			Vel (m/s)		0.80			0.84	



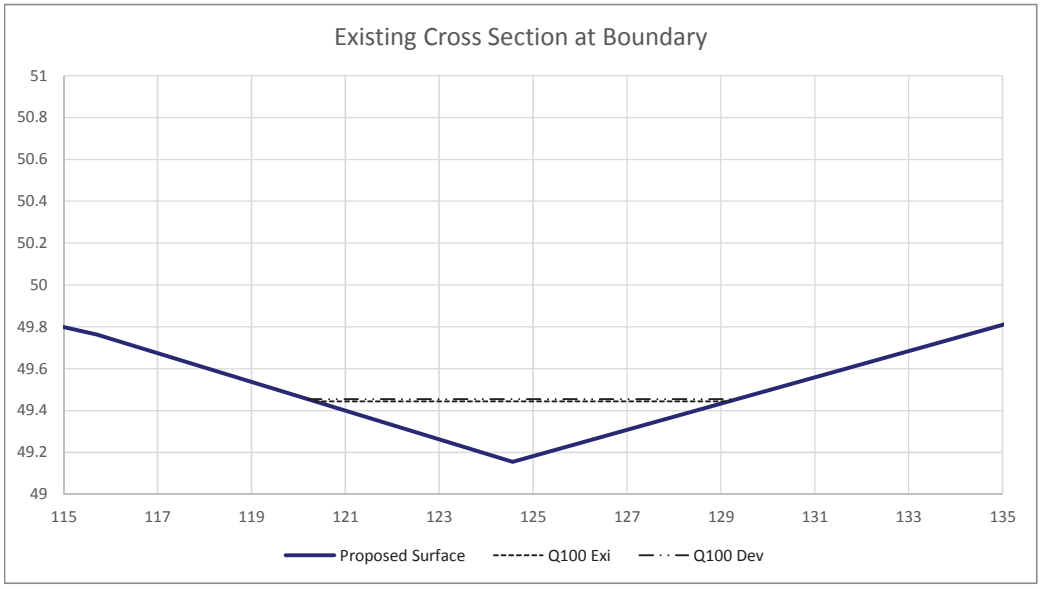
MANNING'S WATER SURFACE EXTENT CALCULATION - 1% AEP

Filename: \\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\9_Technical\Calculations\Comparisor
Date: 8/12/2017
By: GB

Manning's calculation as per Equation 4.2.3 of Australian Rainfall and Runoff (1987)

SECTION

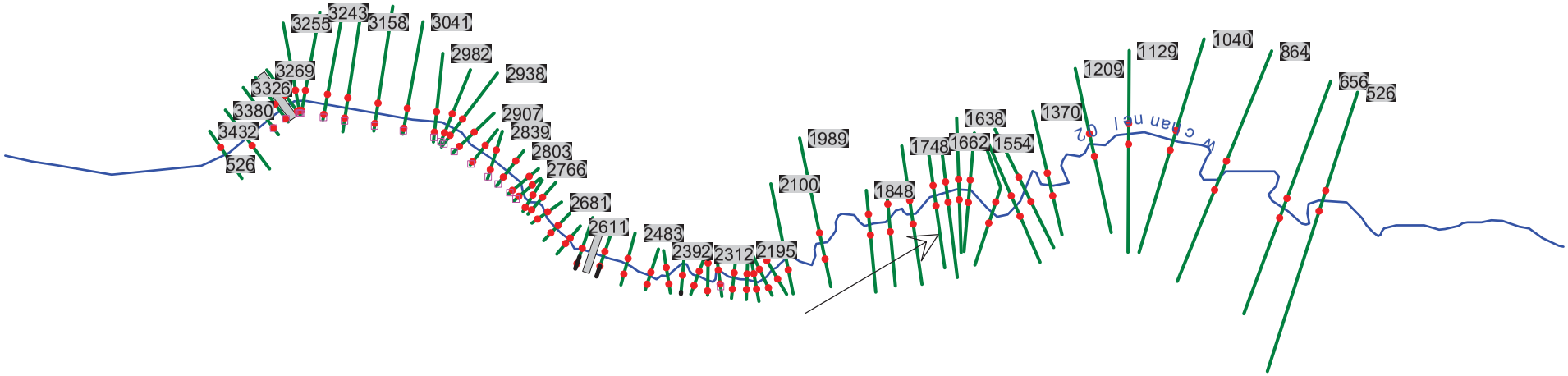
CROSS SECTION DETAILS				Q100 Exi			Q100 Dev		
POINT	CH	Z	n	wA	wP	n x wA	wA	wP	n x wA
1	0	58.555	0.060						
2	22.826	57	0.060						
3	56.384	54	0.060						
4	76.375	52	0.060						
5	90.133	51.091	0.060						
6	102.355	50.436	0.060						
7	115.702	49.763	0.060						
8	124.566	49.155	0.060	0.61	4.23	0.04	0.65	4.37	0.04
9	153.982	51	0.060	0.67	4.63	0.04	0.71	4.78	0.04
10	168.843	52.119	0.060						
11	177.438	52.483	0.060						
12	183.251	52.921	0.060						
13	198.203	53	0.060						
14	208.974	53.362	0.060						
15	246.857	54.36	0.060						
16	279.612	55.453	0.060						
17	298.59	55.873	0.060						
18	313.498	55.984	0.060						
20	332.574	55.889	0.060						
21	344.832	55.632	0.060						
22	359.512	55.724	0.060						
				wA	wP	n x wA	wA	wP	n x wA
			TOTAL	1.280008	8.858582	0.076801	1.365879	9.150902	0.081953
	S								
	0.0359			R	n	Q	R	n	Q
				0.144494	0.060	1.11	0.149262	0.060	1.21
				Q100	1.11		Q100	1.21	
	45.971		WSL		49.445			49.45416	
			Calculated by Manning's Equation		1.11			1.21	
			Vel (m/s)		0.87			0.89	



ROL1 – RIVERSIDE, JIMBOOMBA

Appendix D HEC RAS Modelling Information

CELESTINO PTY LTD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3158
3041
2982
2938
3269
3326
3380
3432
526
2907
2839
2803
2766
2681
2611
2483
2392
2312
2195
2100
1989
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1370
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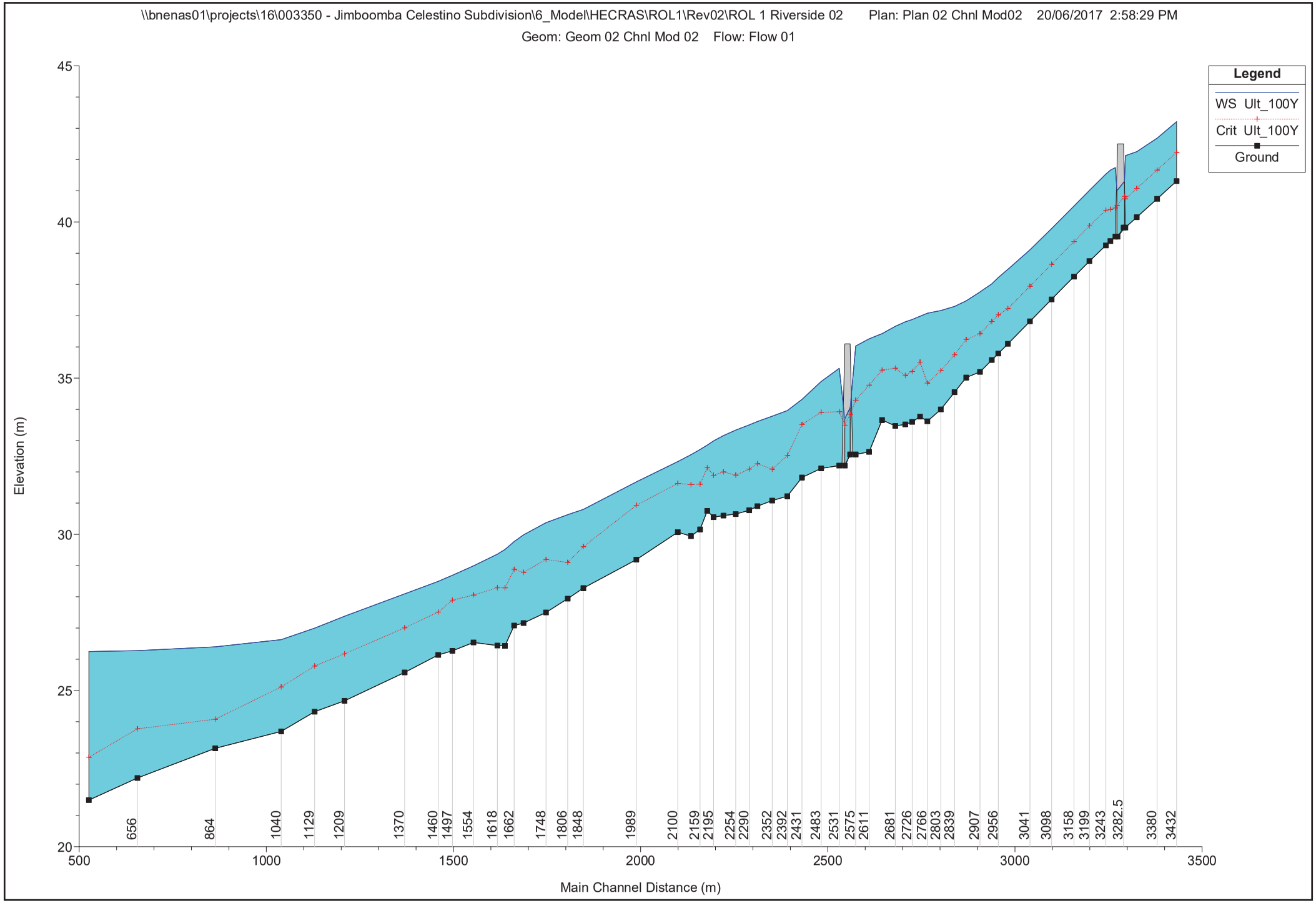
656
526
W c han ne l 02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Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
Legend
WS Ult_100Y
Crit Ult_100Y
Ground
Elevation (m)
Main Channel Distance (m)
45
40
35
30
25
20
500
1000
1500
2000
2500
3000
3500
656
864
1040
1129
1209
1370
1460
1497
1554
1618
1662
1748
1806
1848
1989
2100
2159
2195
2254
2290
2352
2392
2431
2483
2531
2575
2611
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3380
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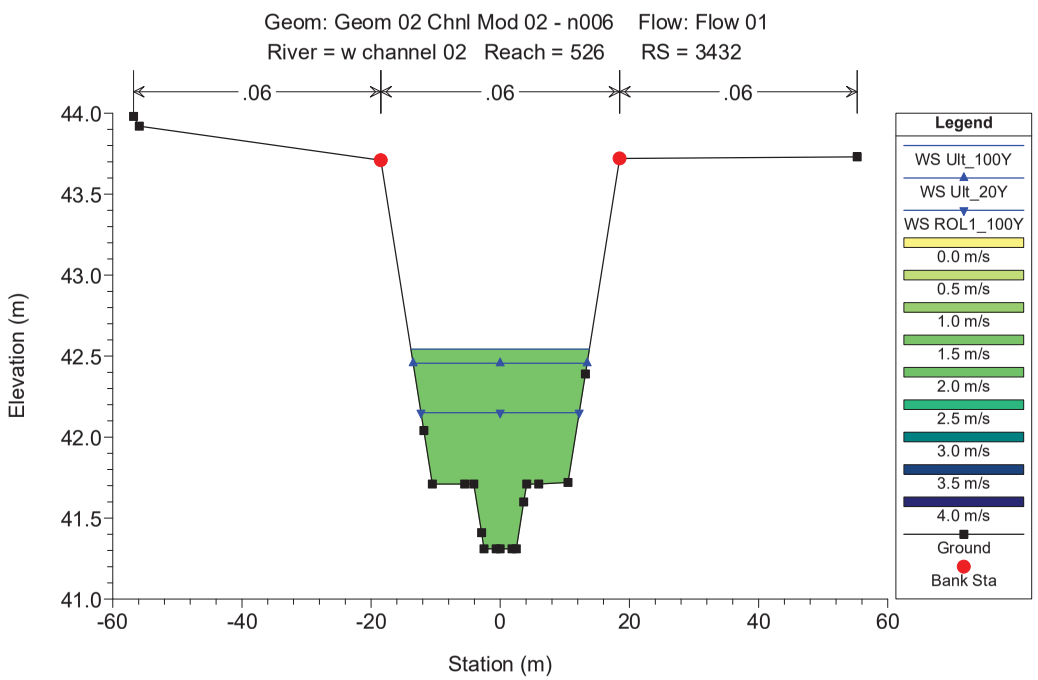

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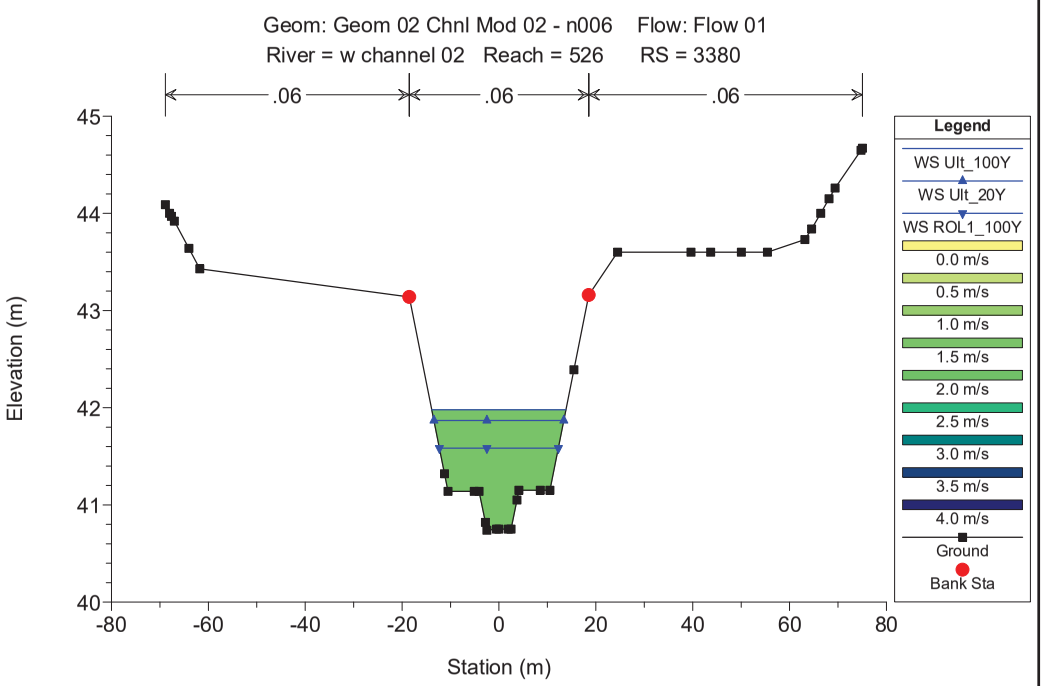

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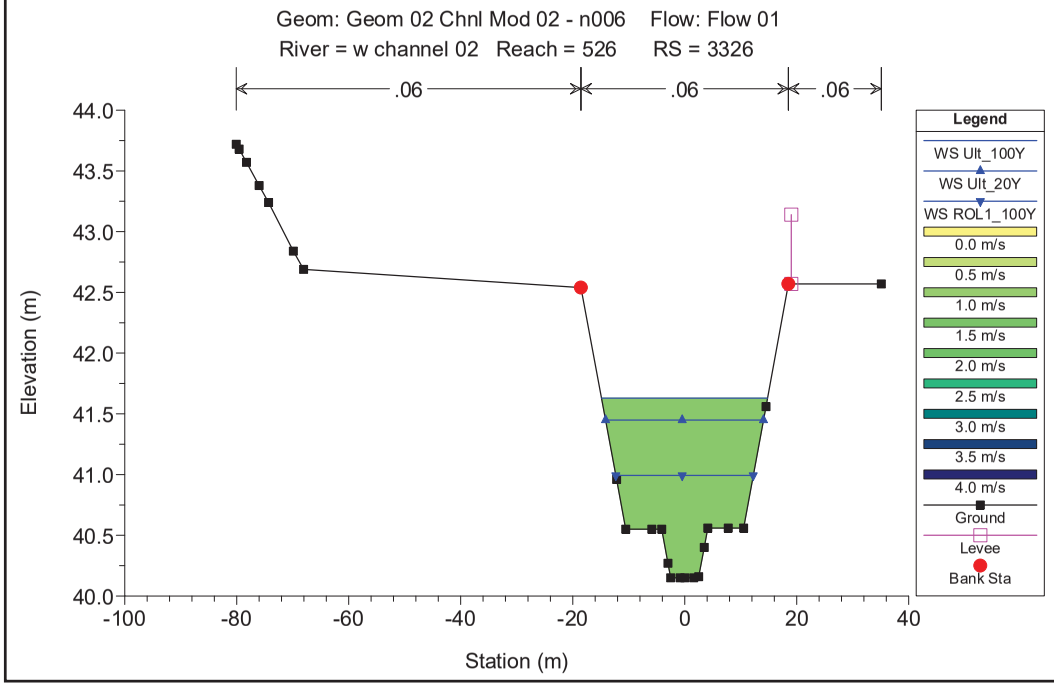

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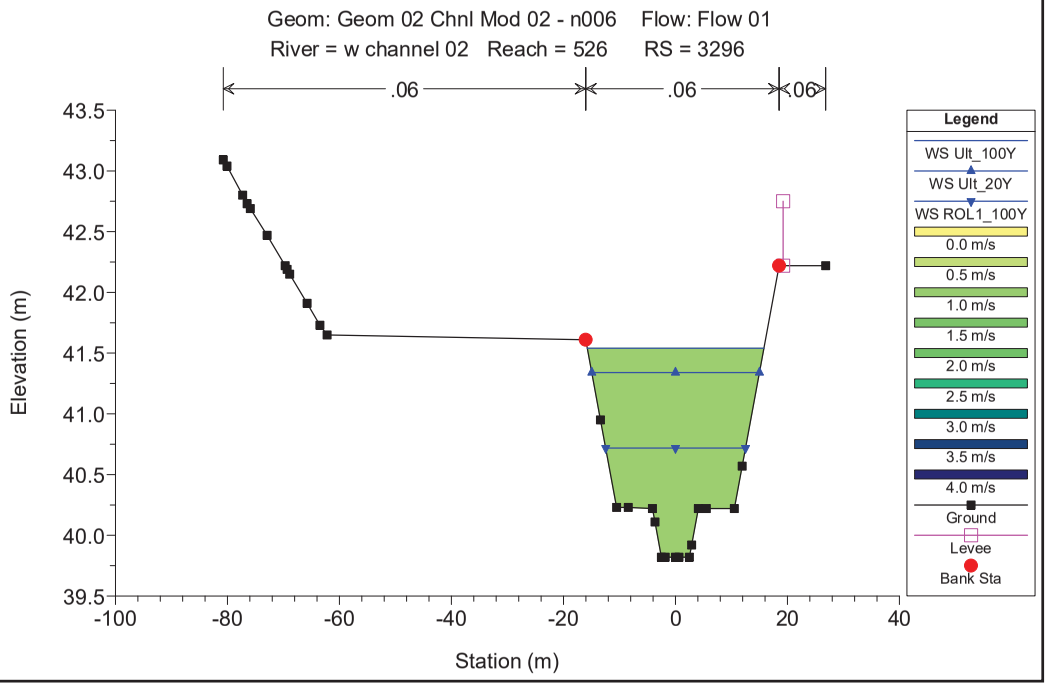
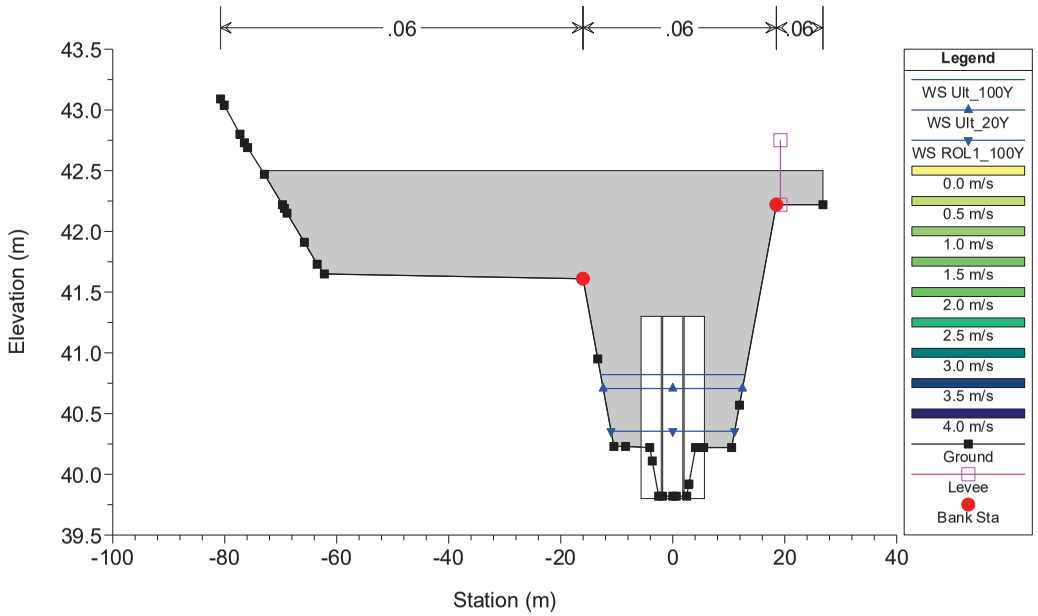


Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3282.5 Culv



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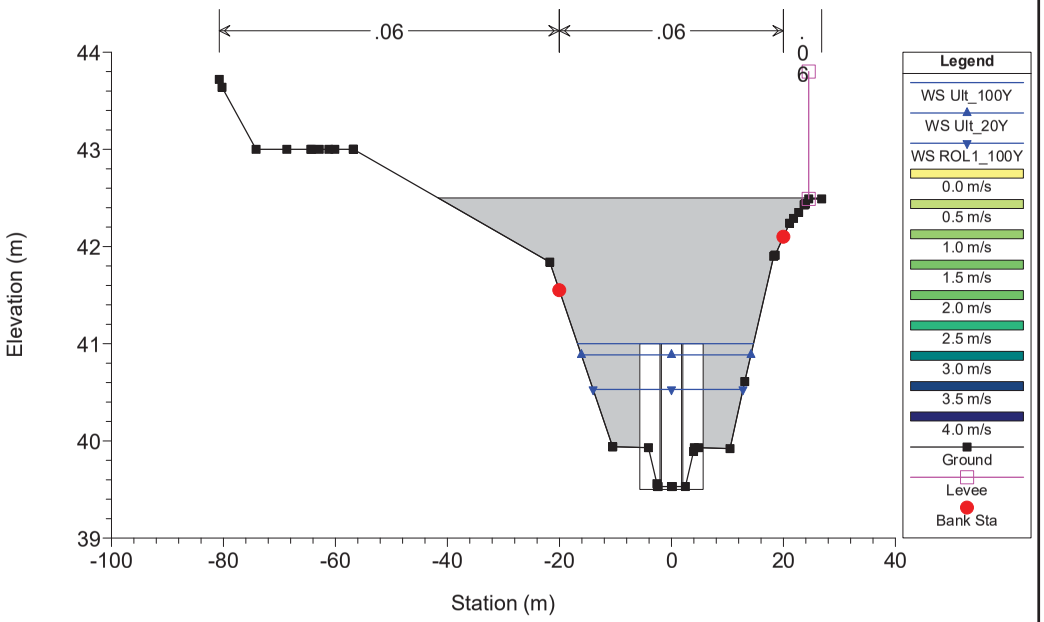
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3282.5 Culv



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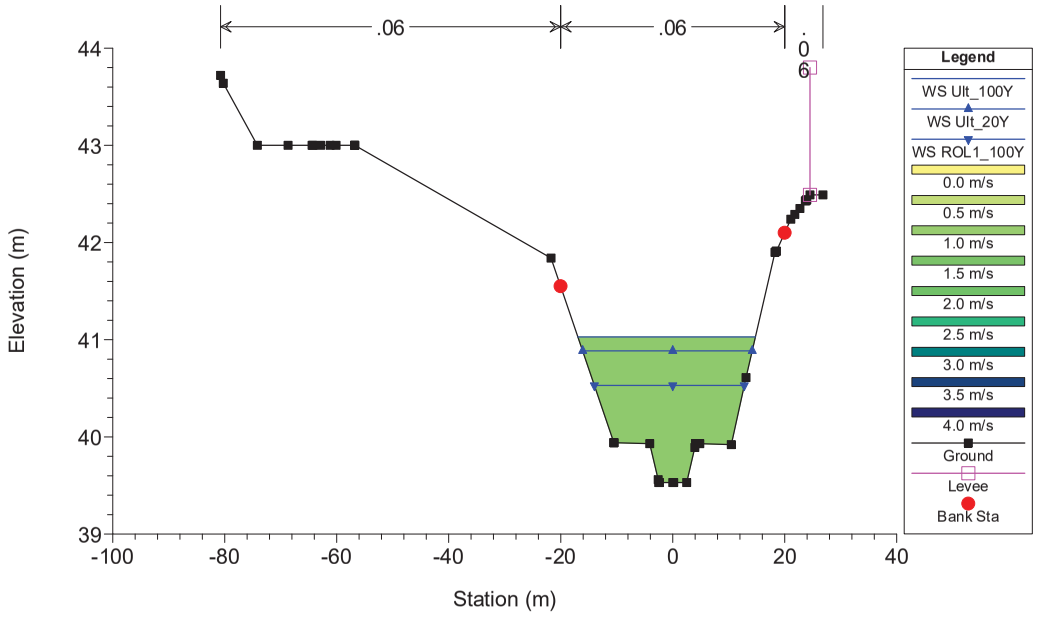
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3269



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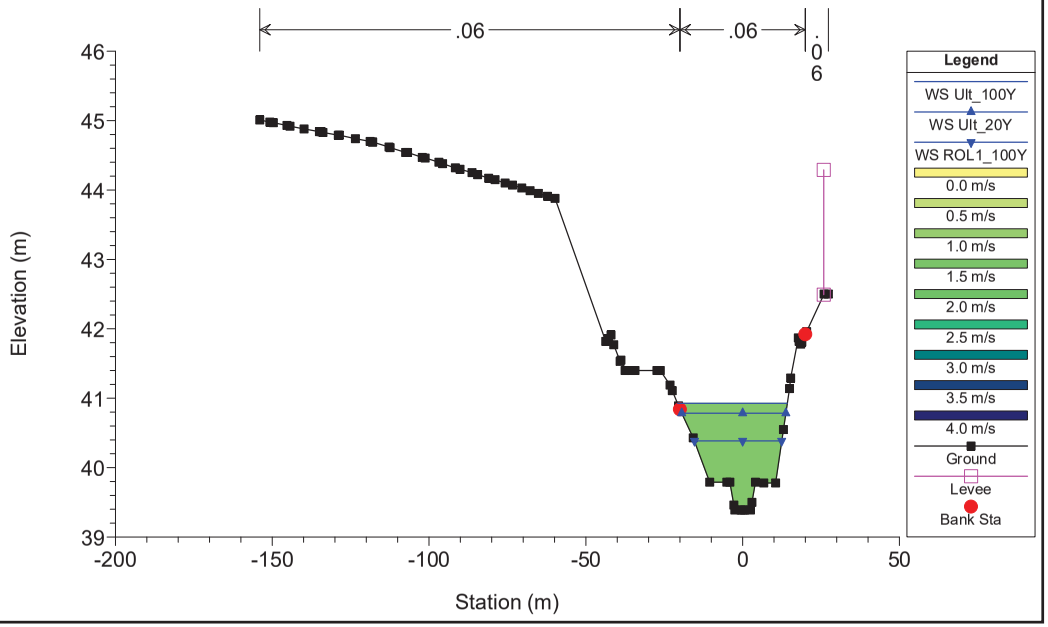
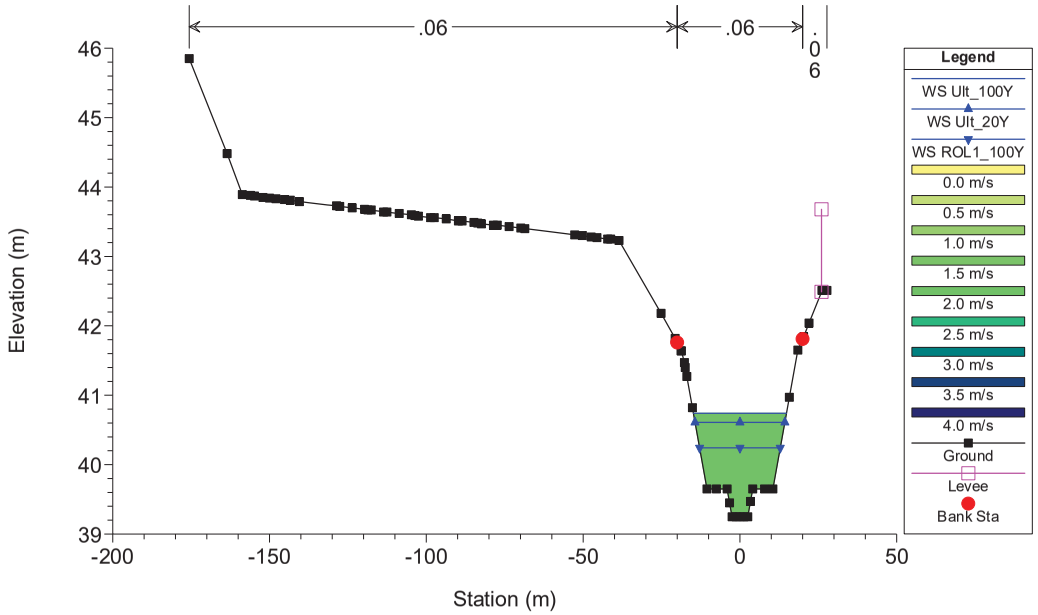
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3255

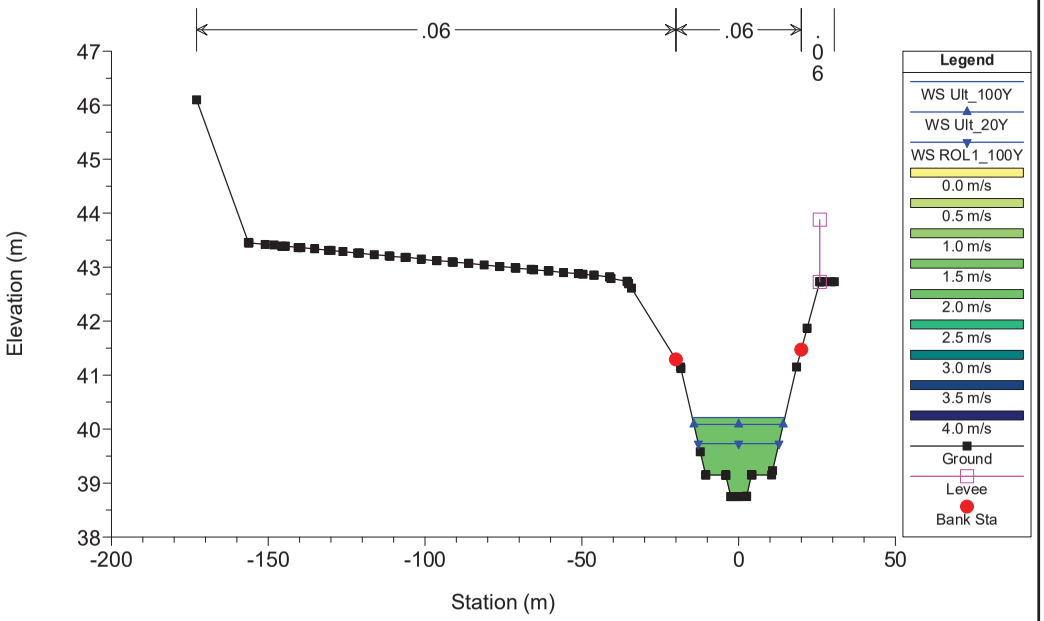


Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3243



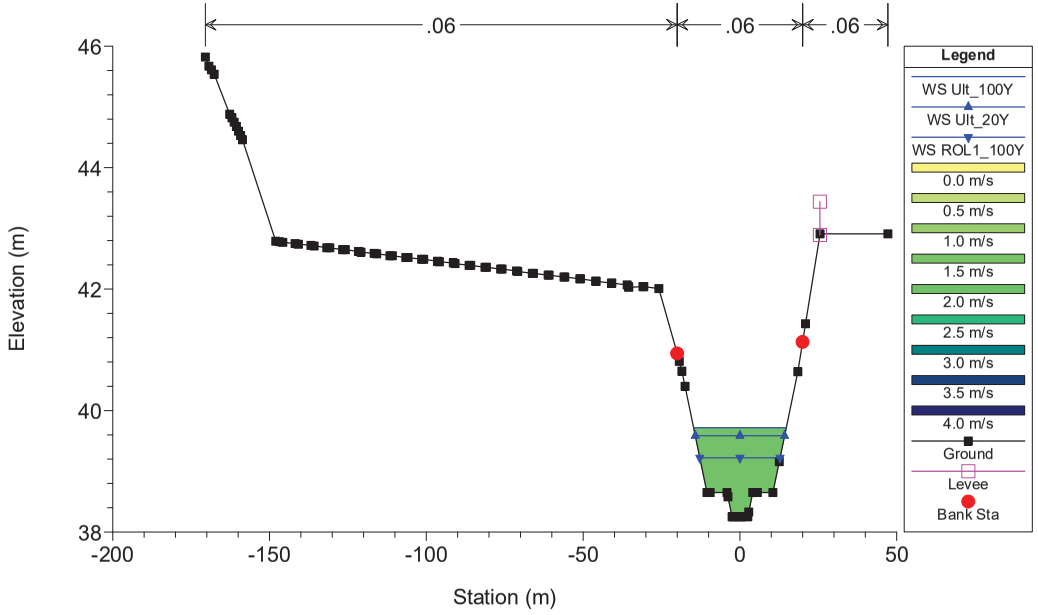
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3199



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3158



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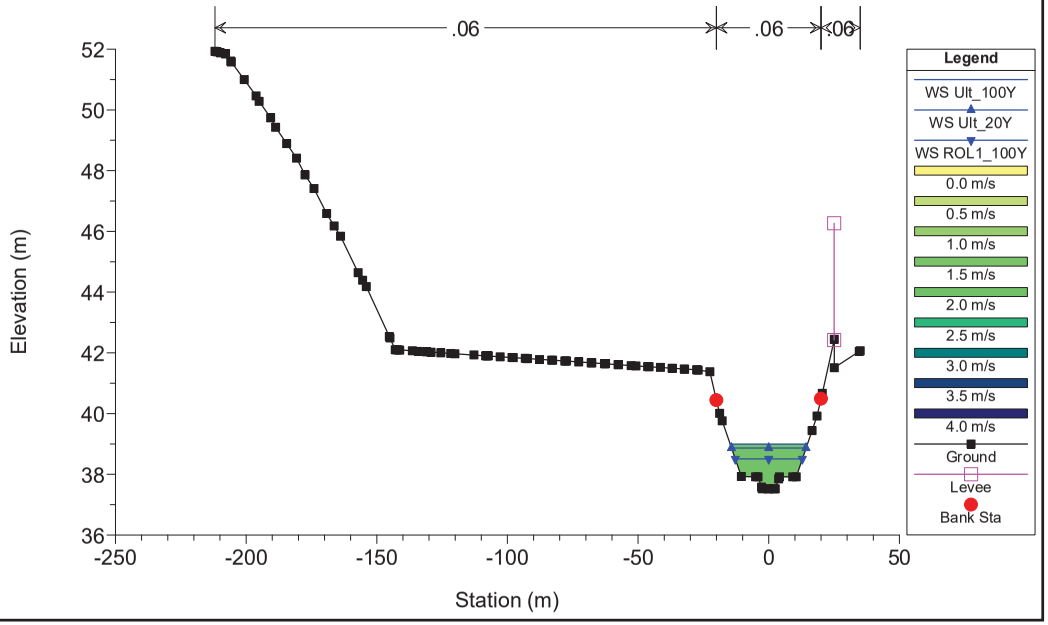
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3098



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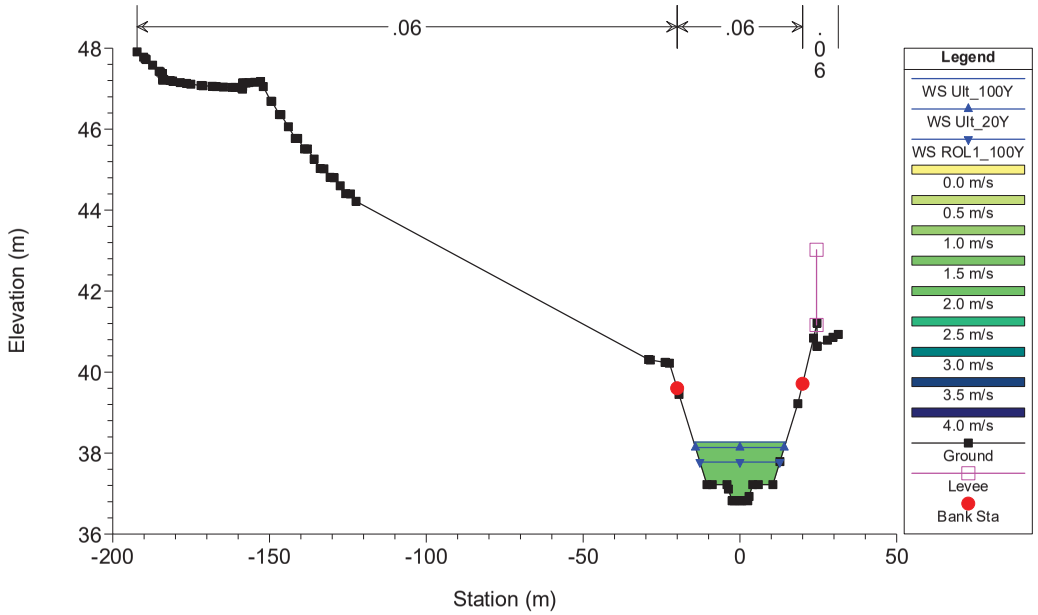
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3041



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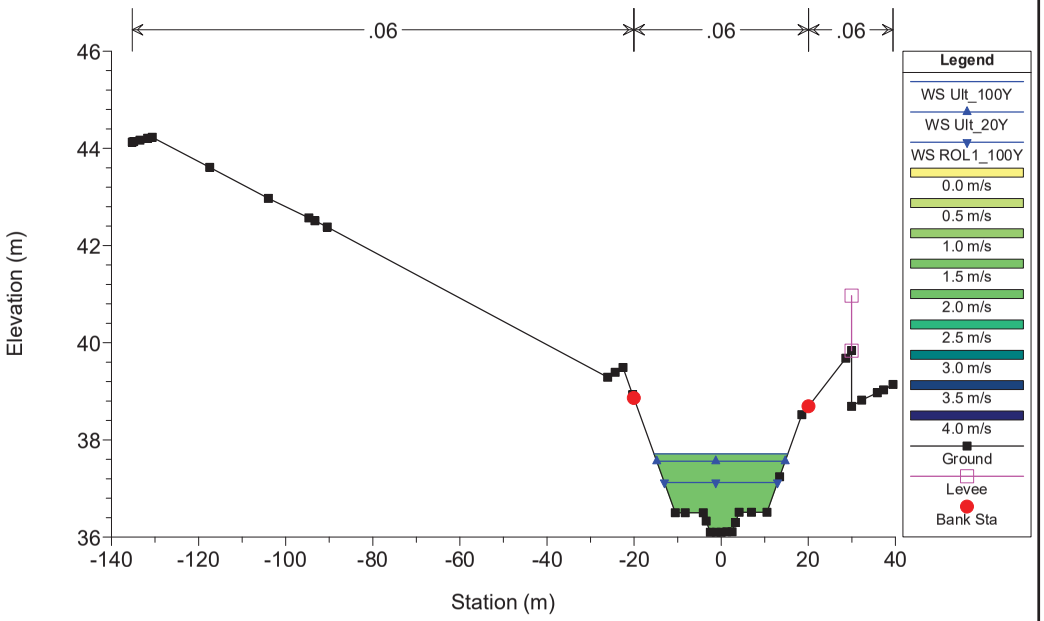
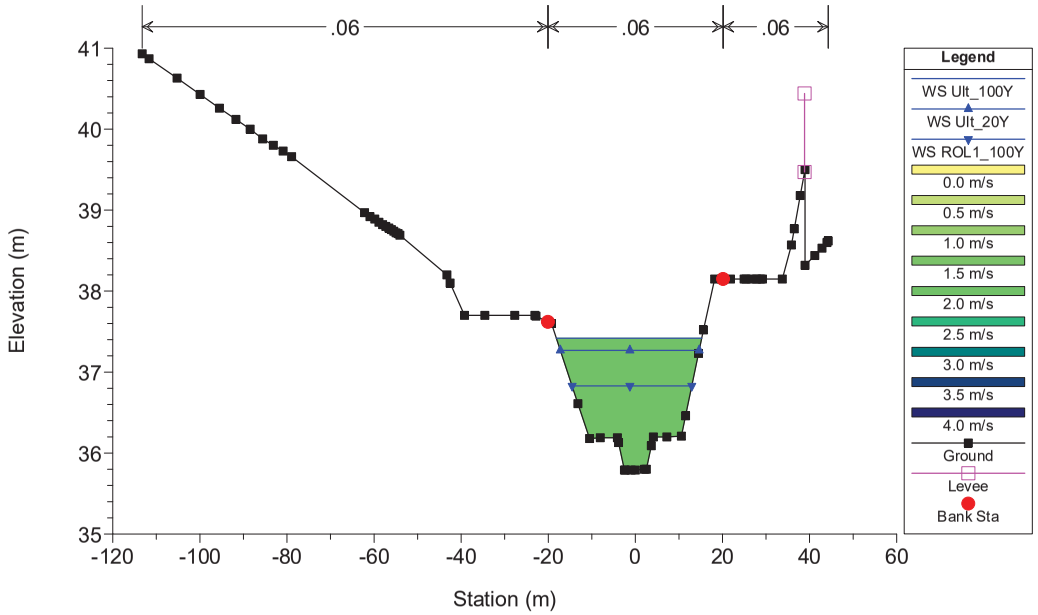
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2982



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2956



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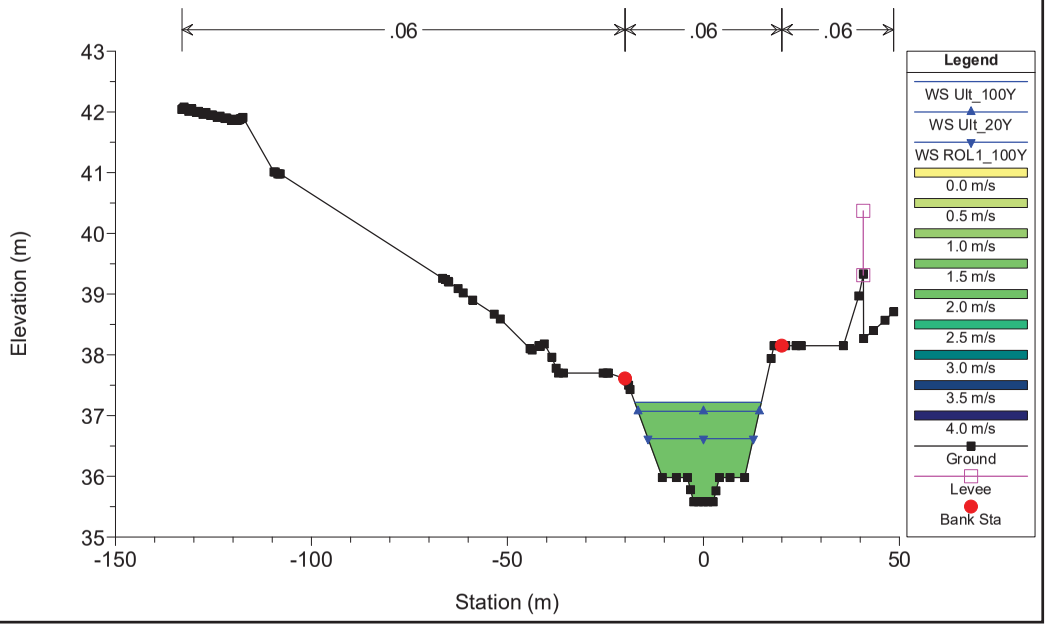
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2938



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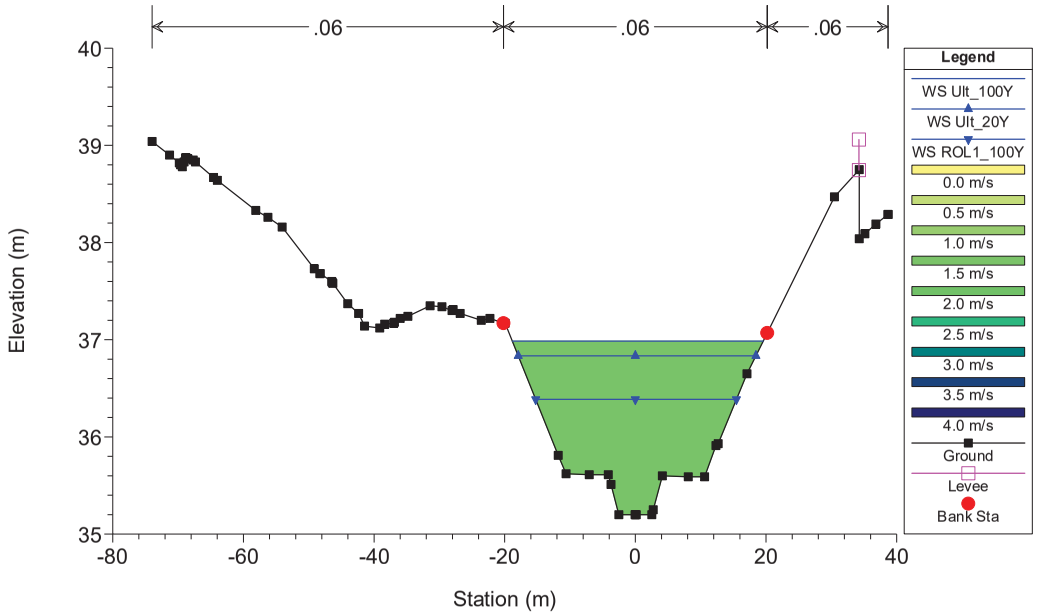
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2907



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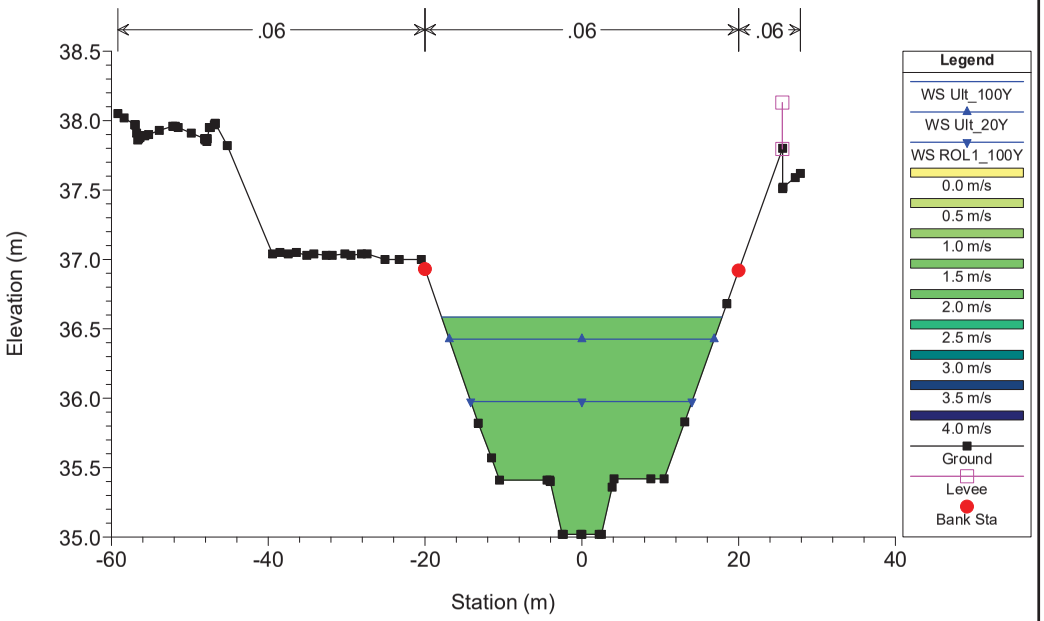
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2870



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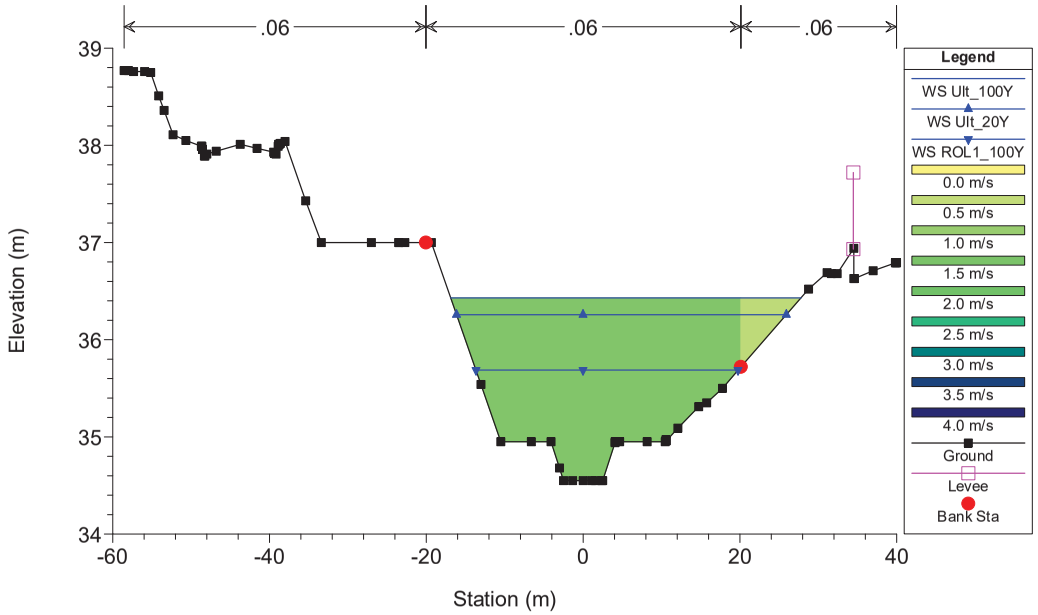
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2839



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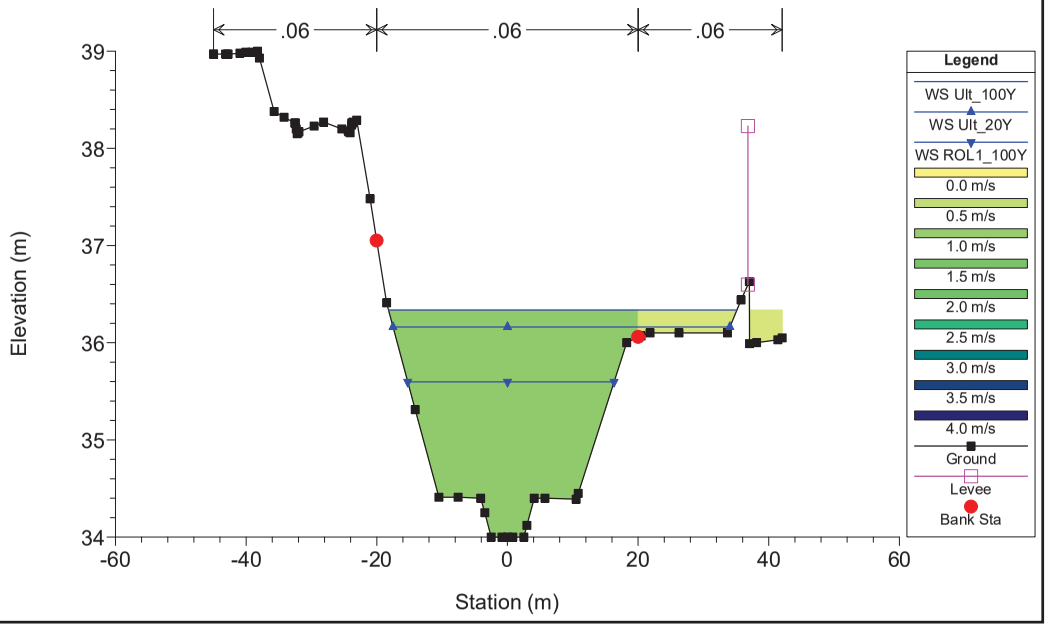
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2803



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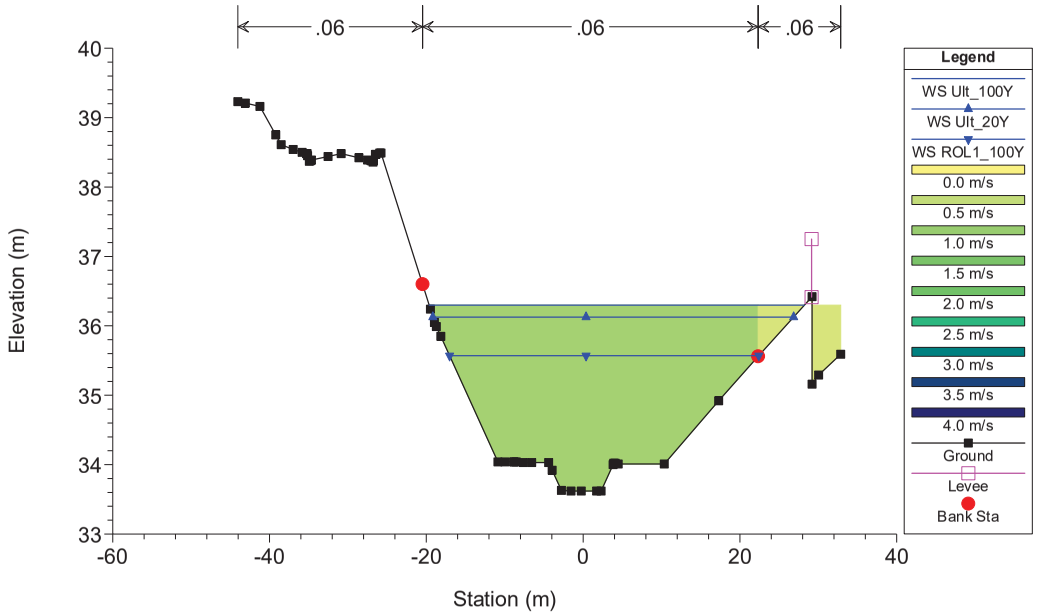
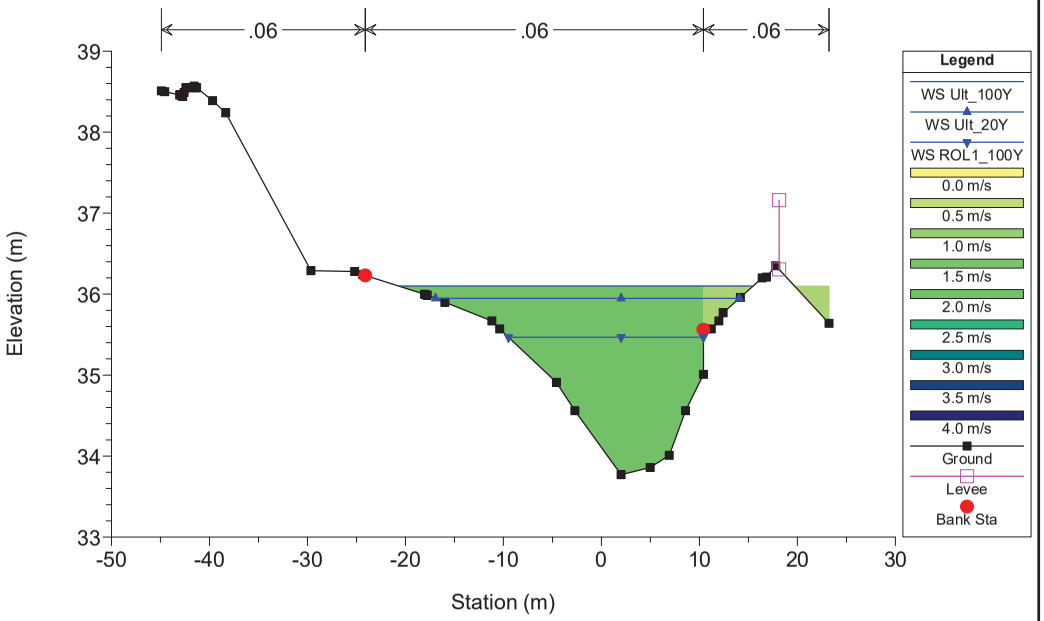
River = w channel 02 Reach = 526 RS = 2766



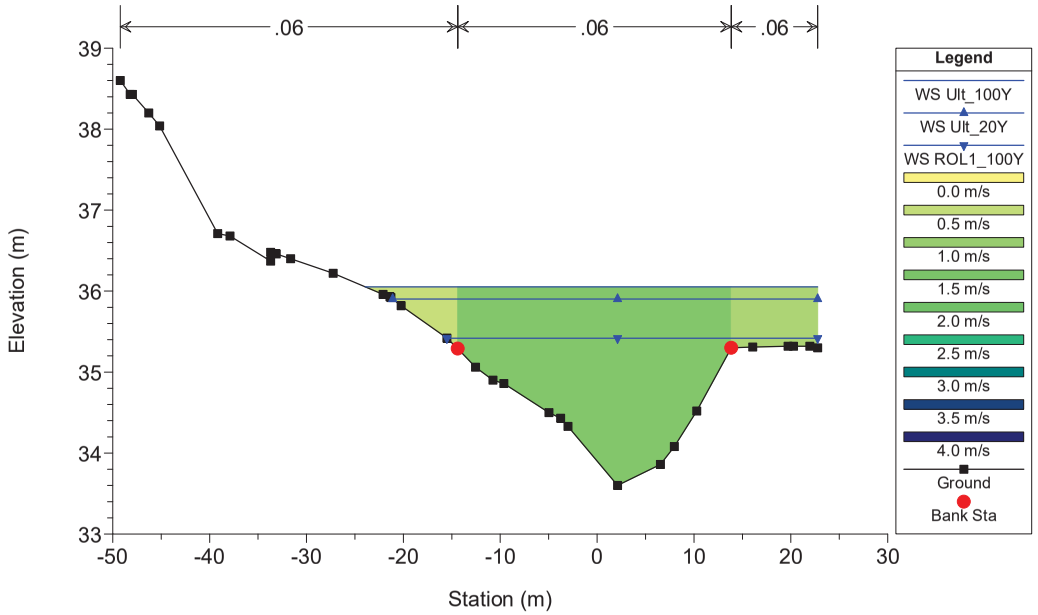
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2747



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2726



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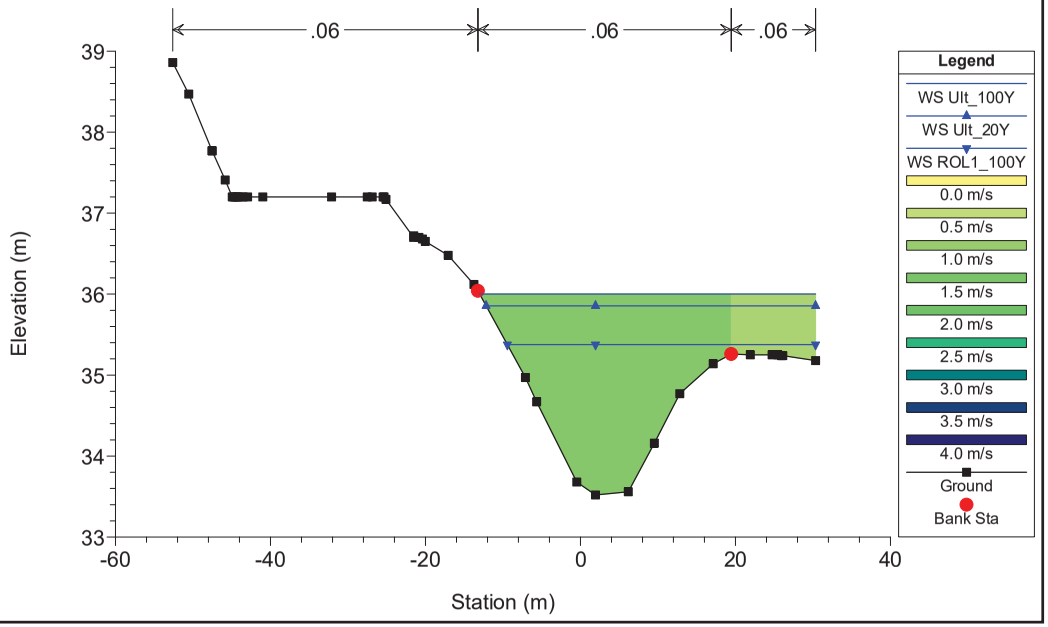
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2707



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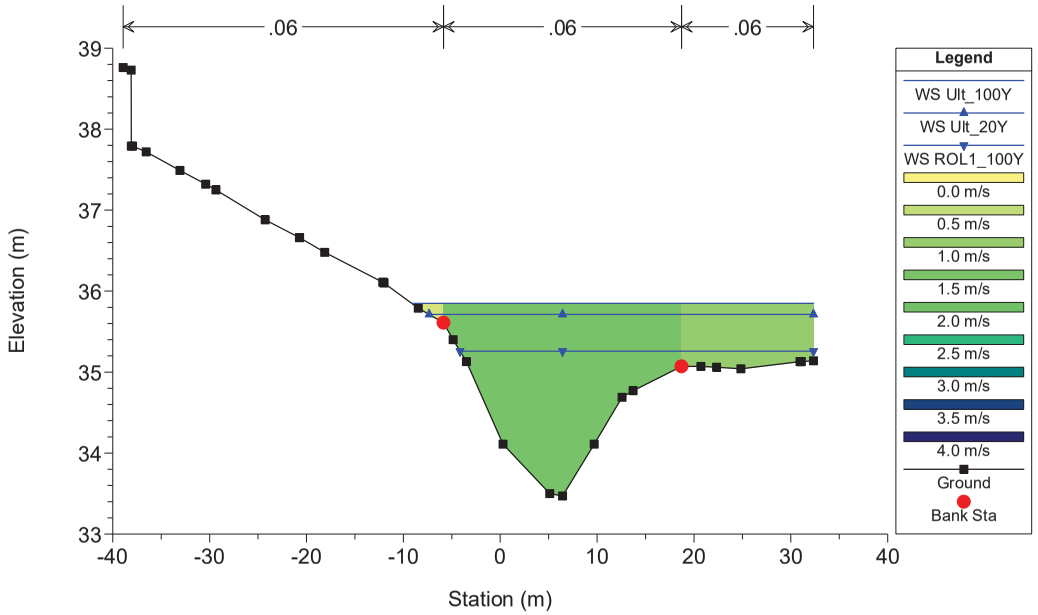
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2681



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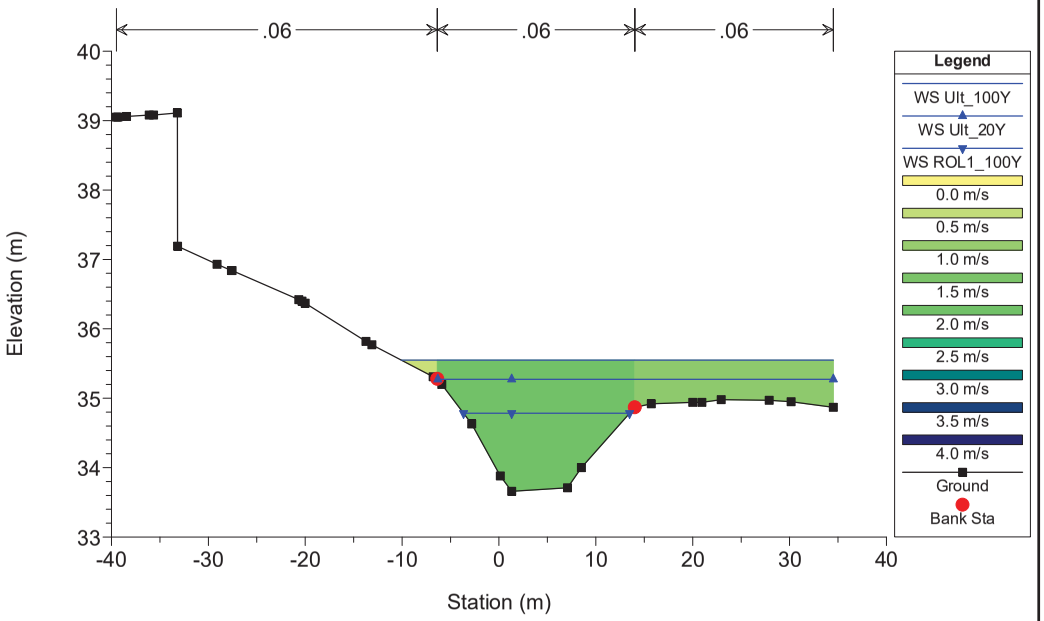
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2645



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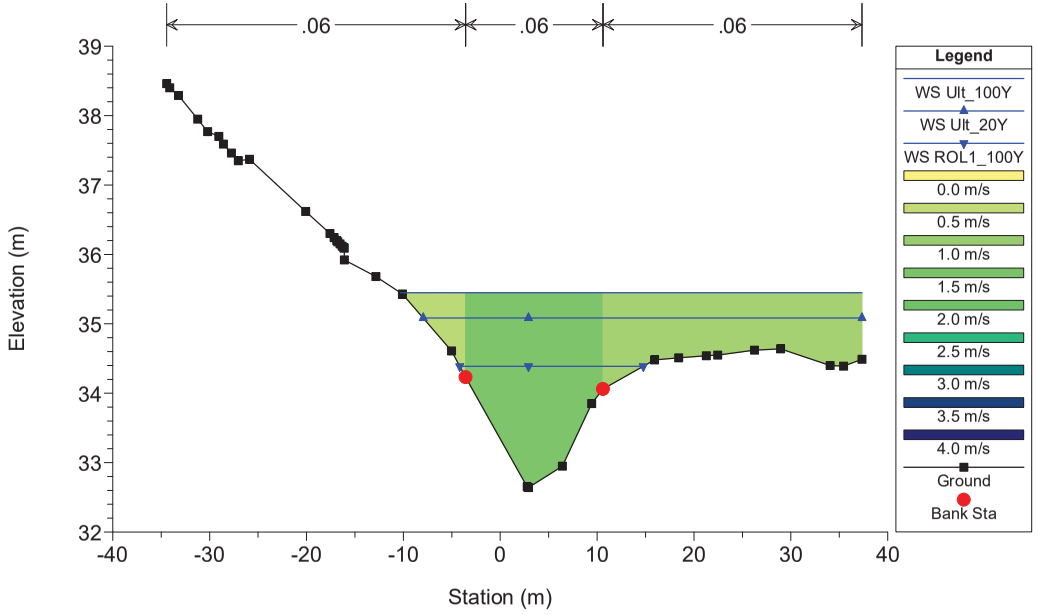
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2611



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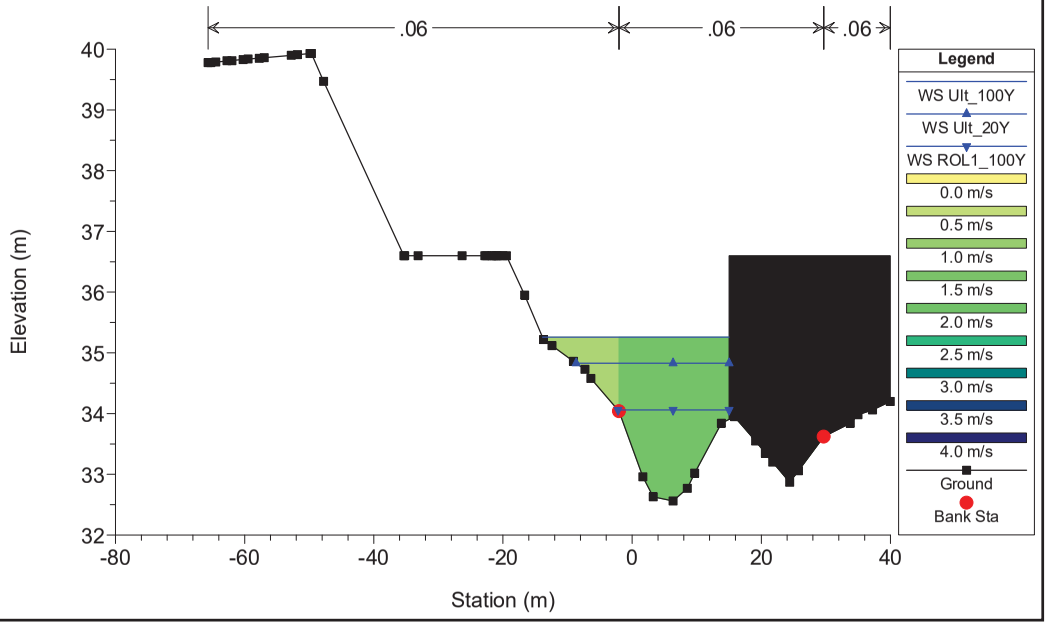
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2575



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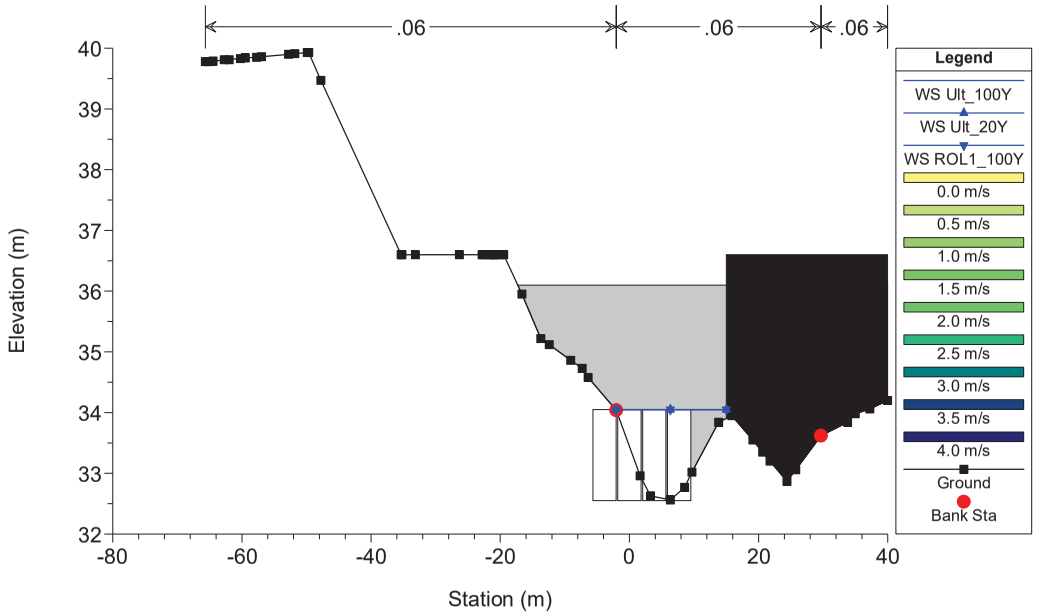
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2553 Culv



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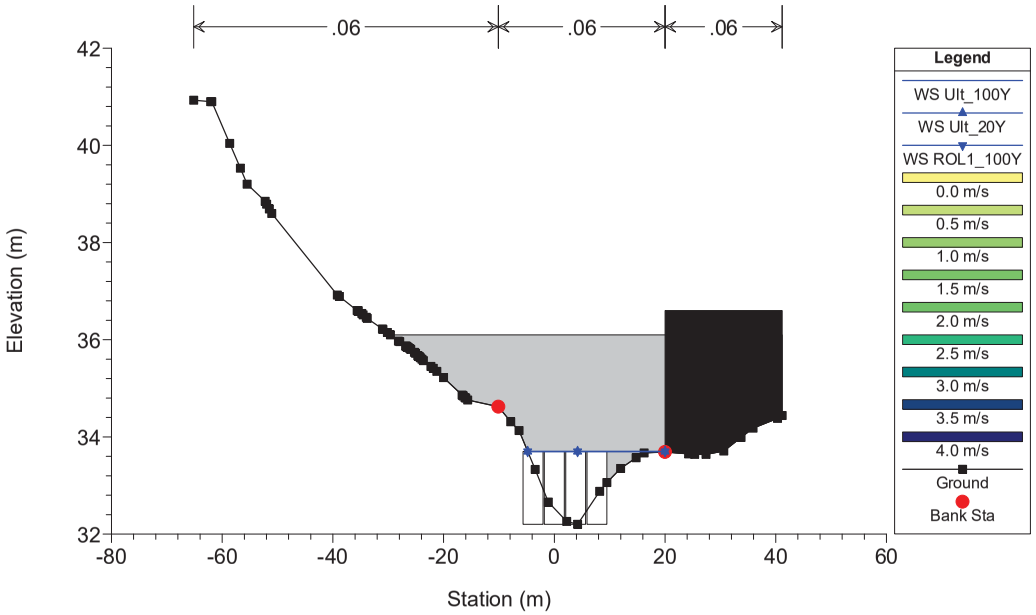
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2553 Culv



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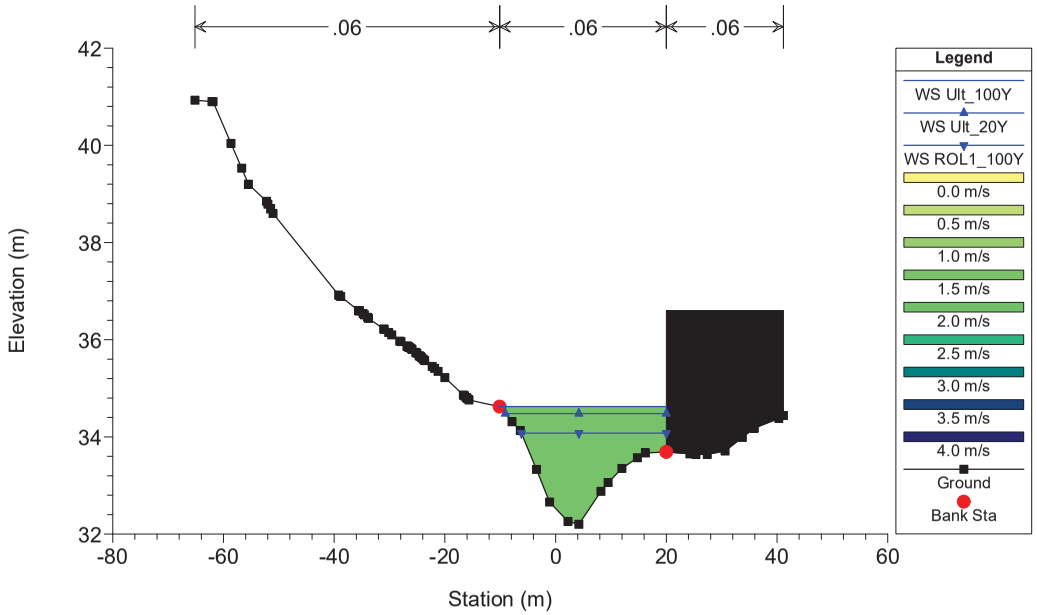
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2531



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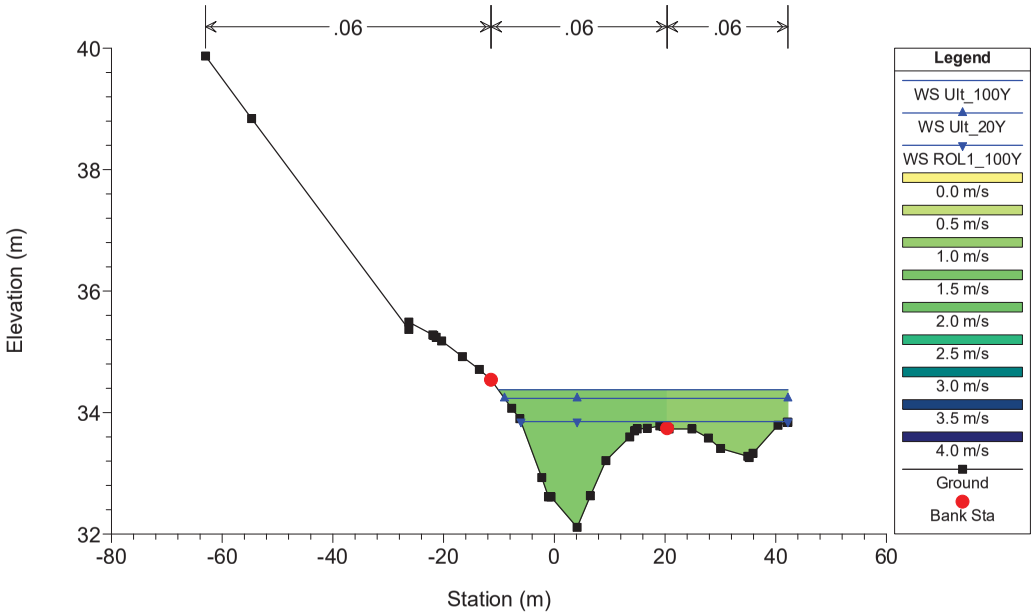
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2483



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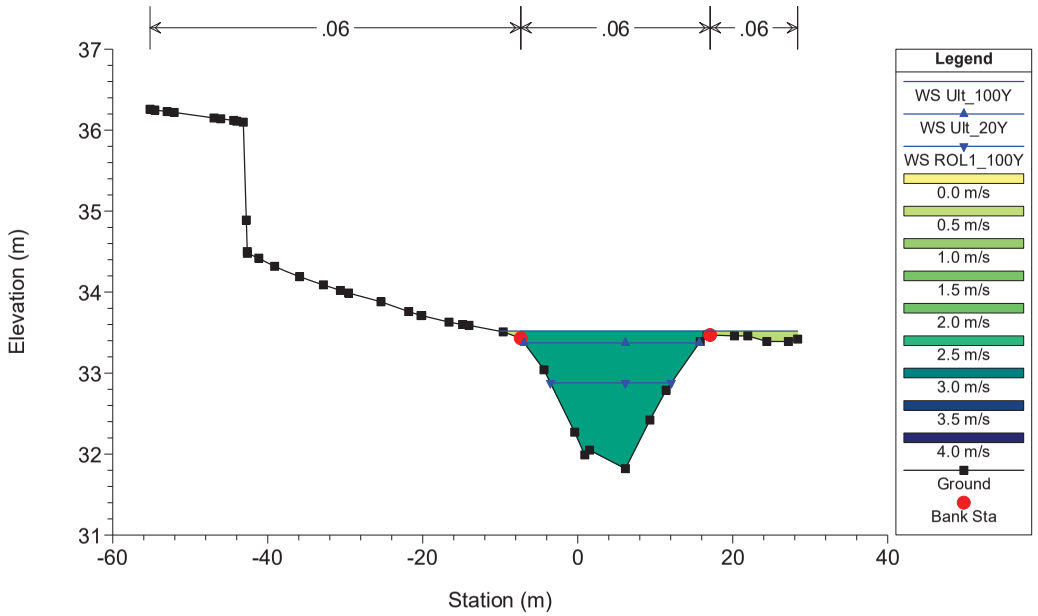
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2431



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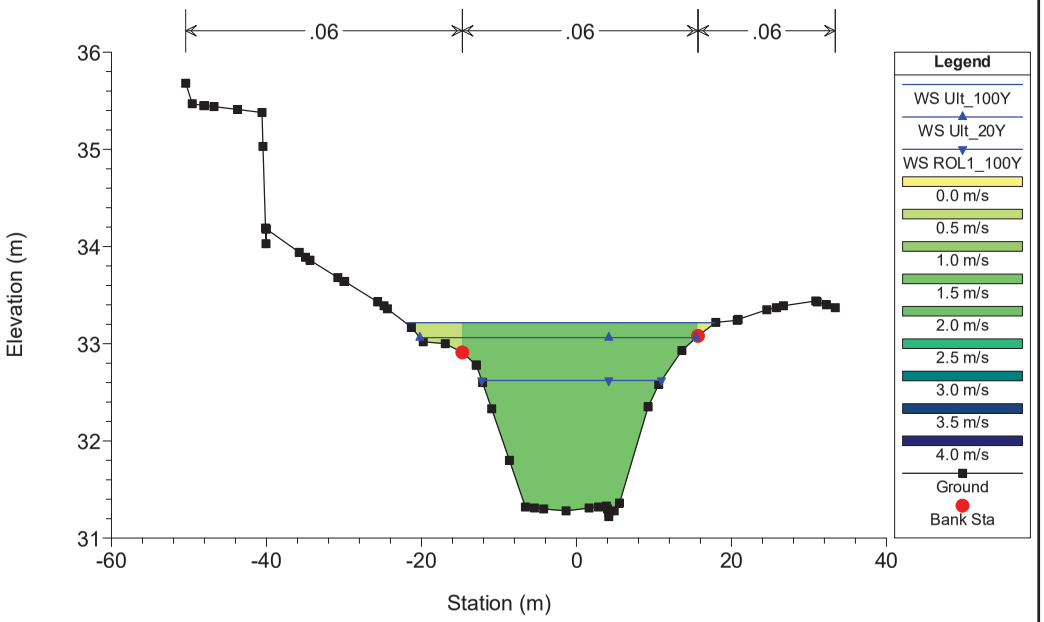
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2392



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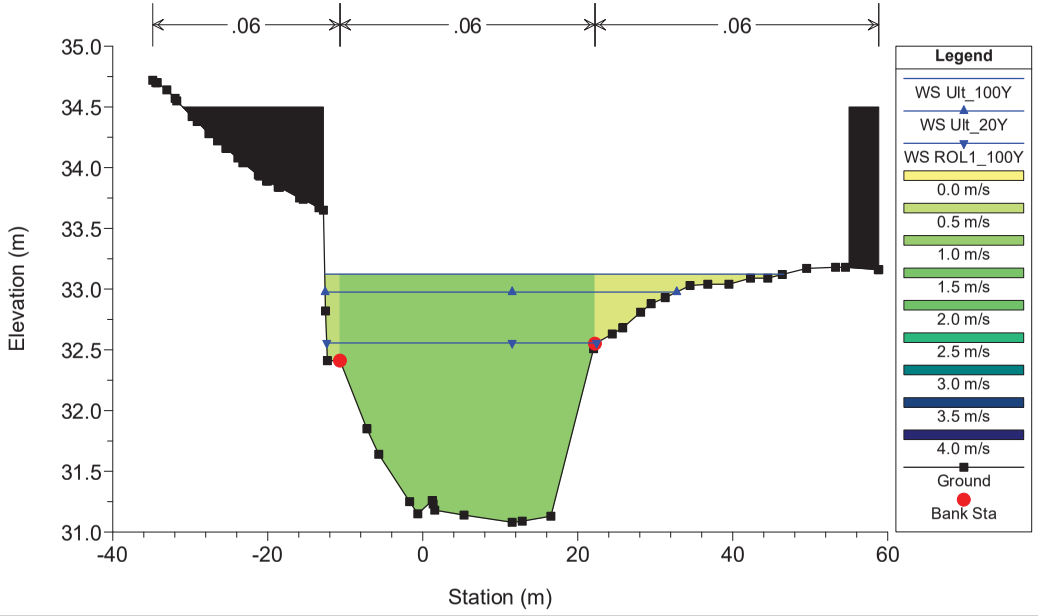
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2352



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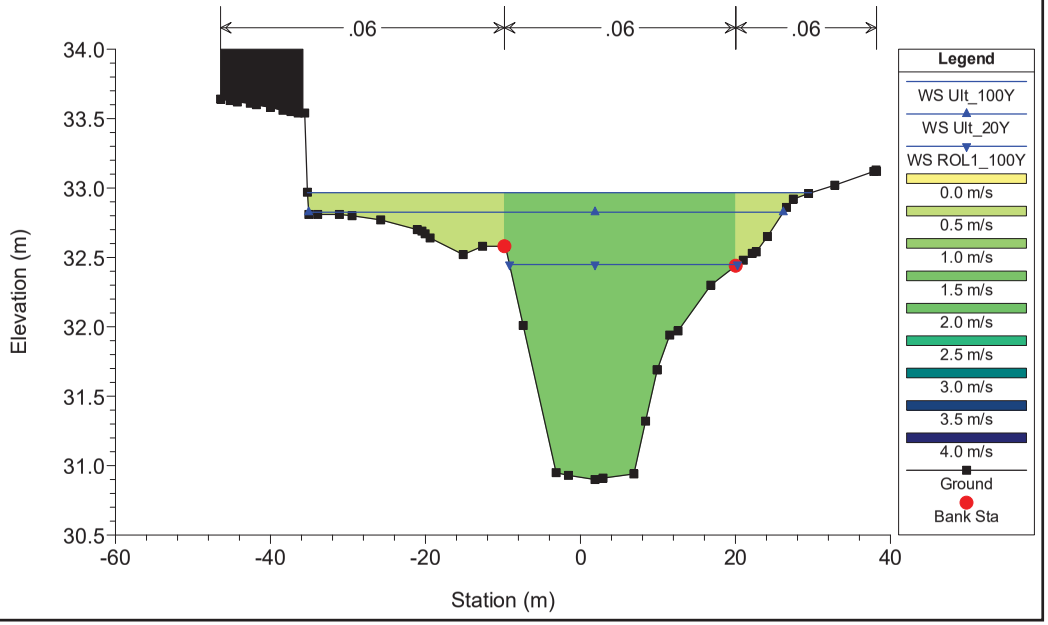
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2312



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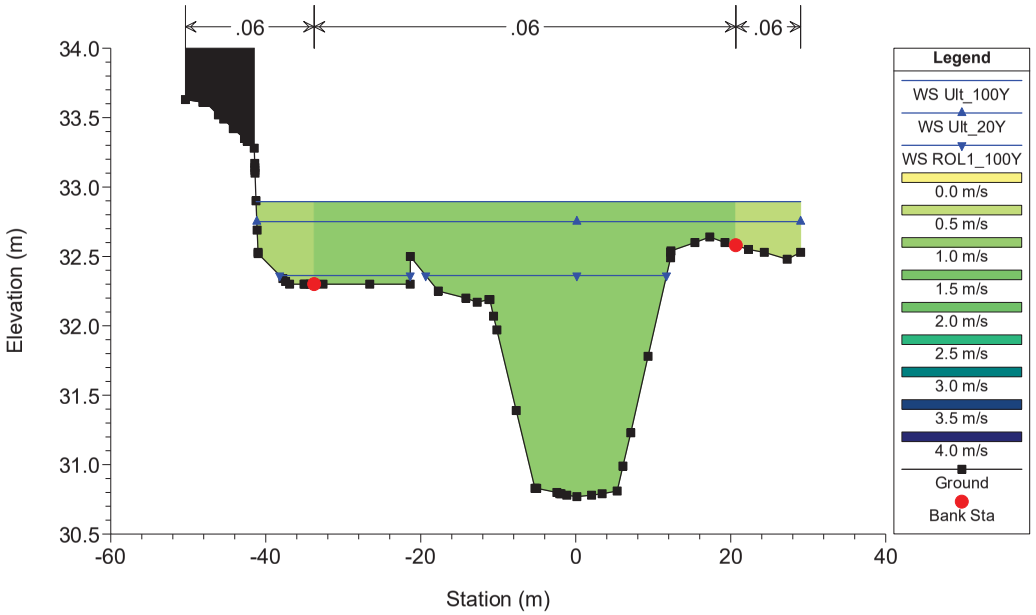
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2290



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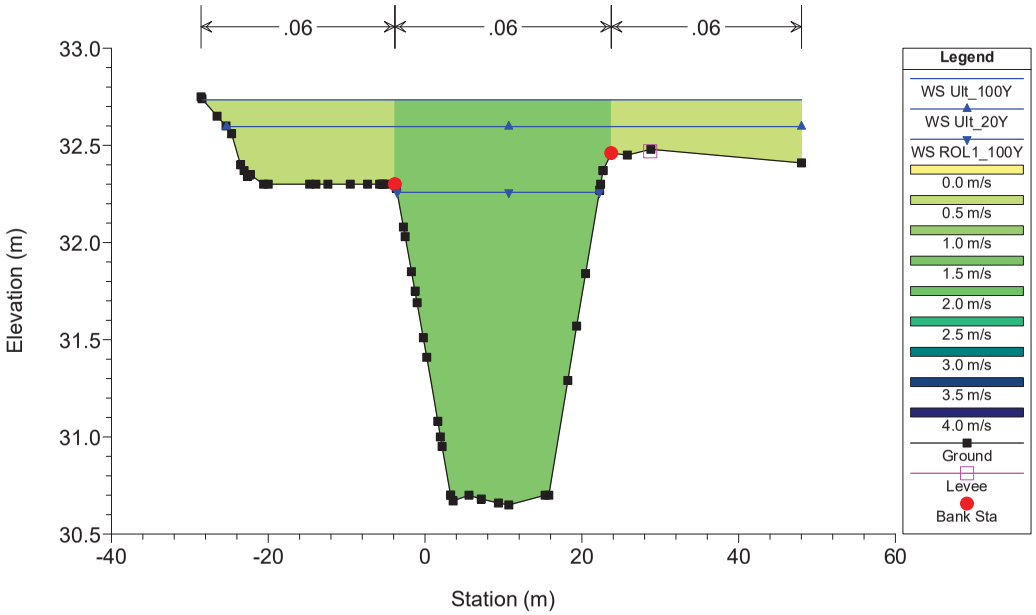
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2254



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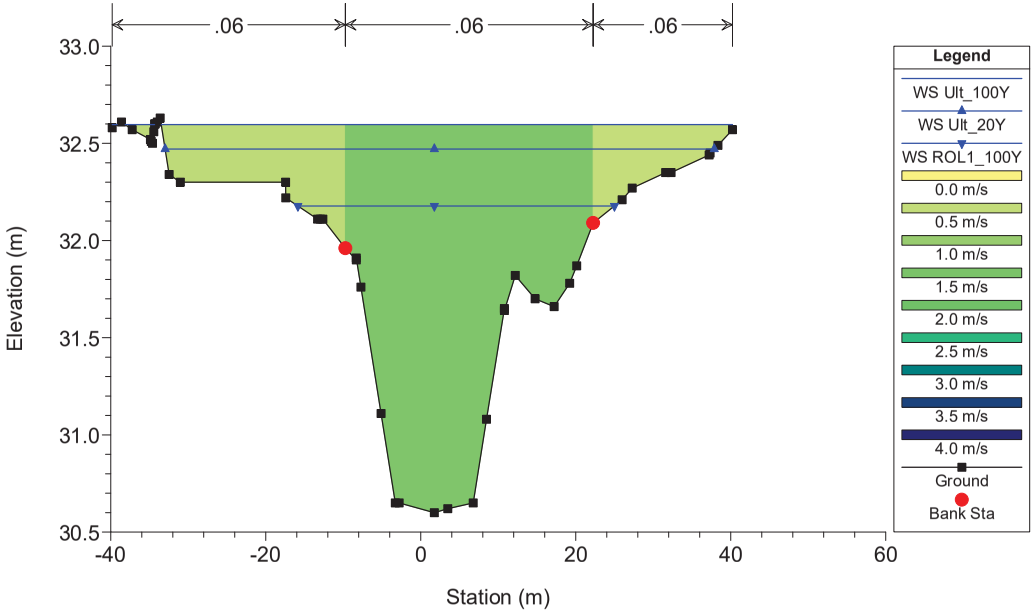
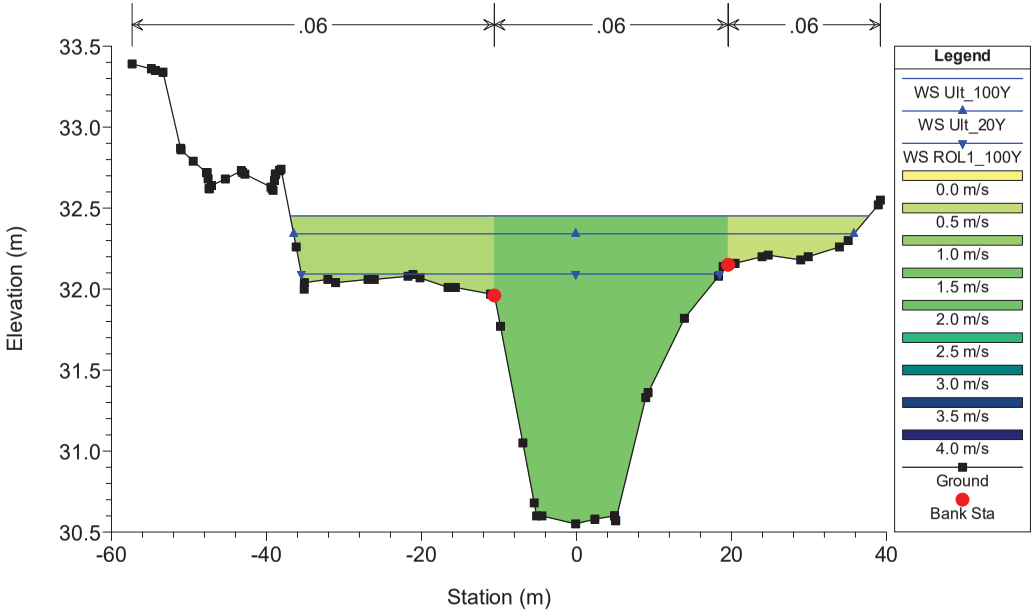
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2222



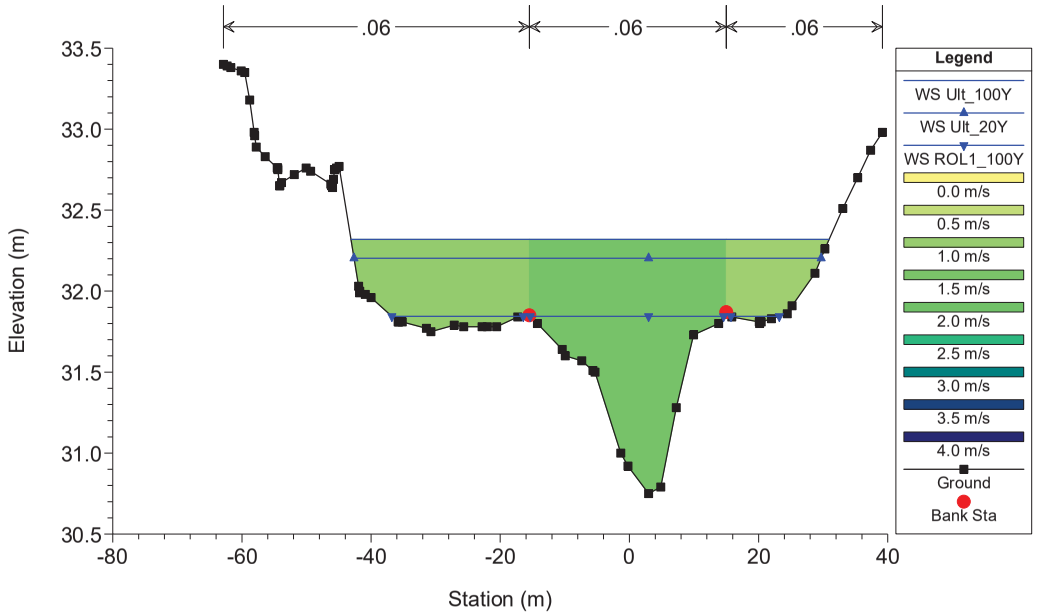
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2195



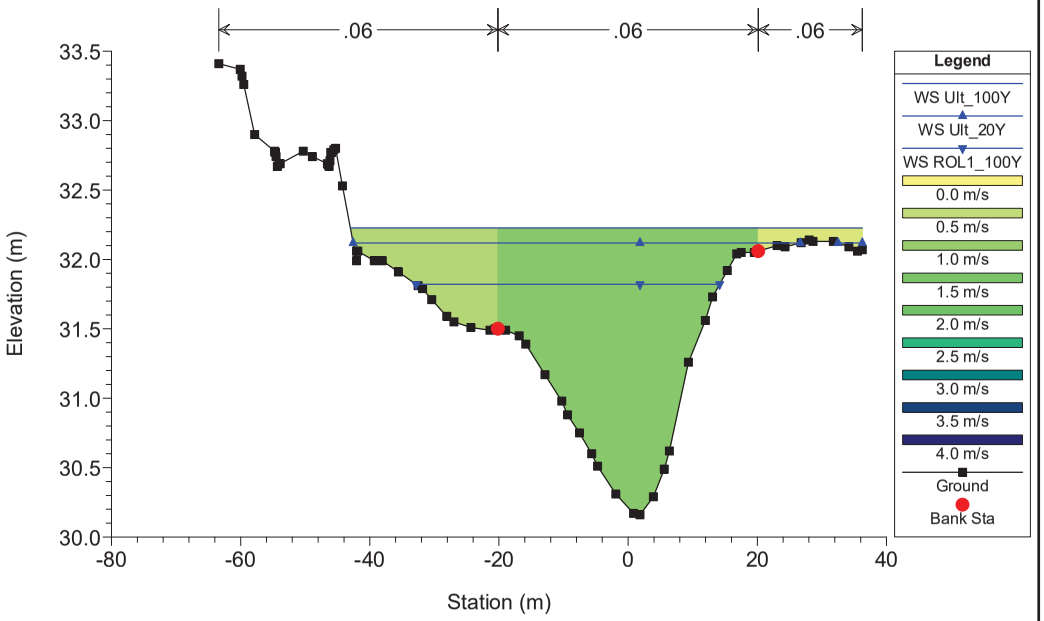
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2178



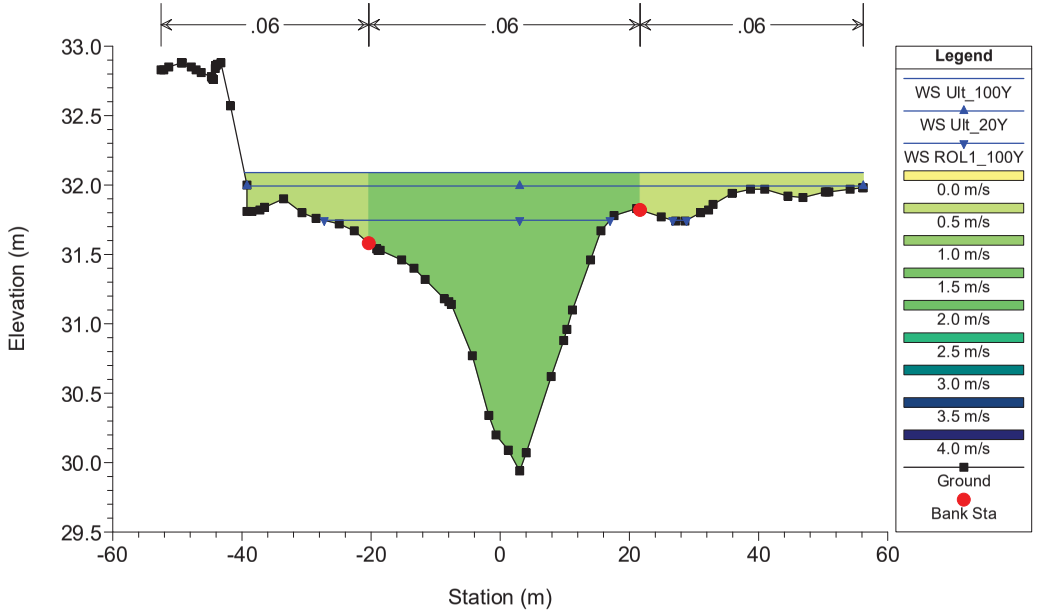
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2159



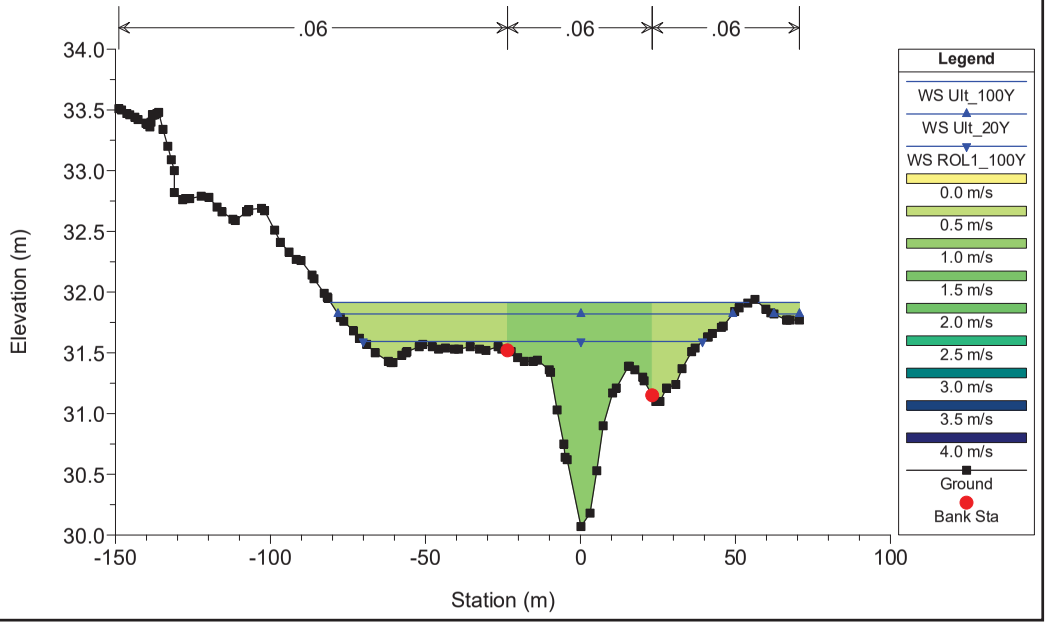
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2135

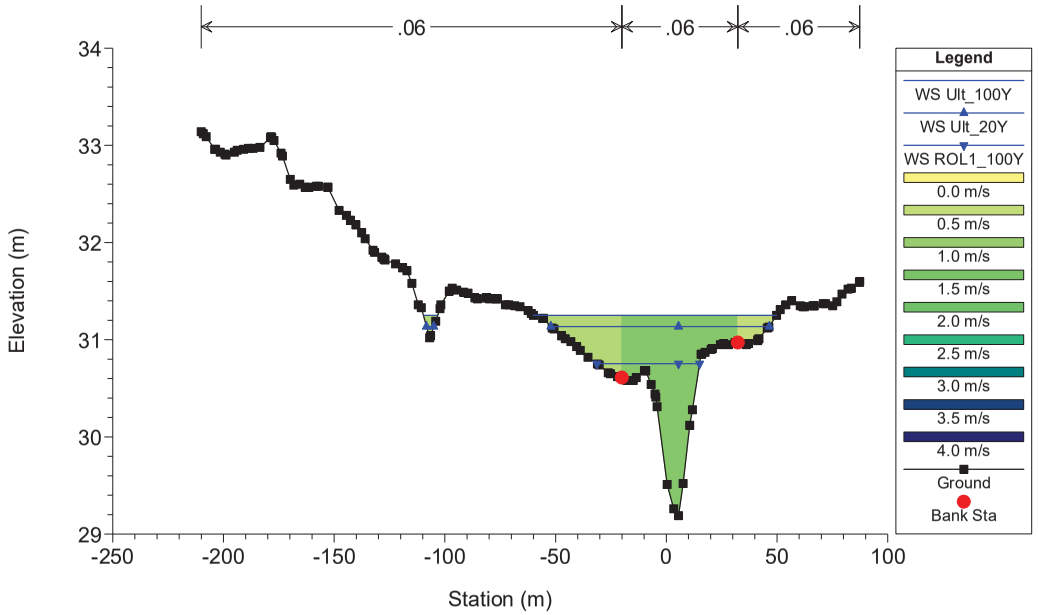


\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2100

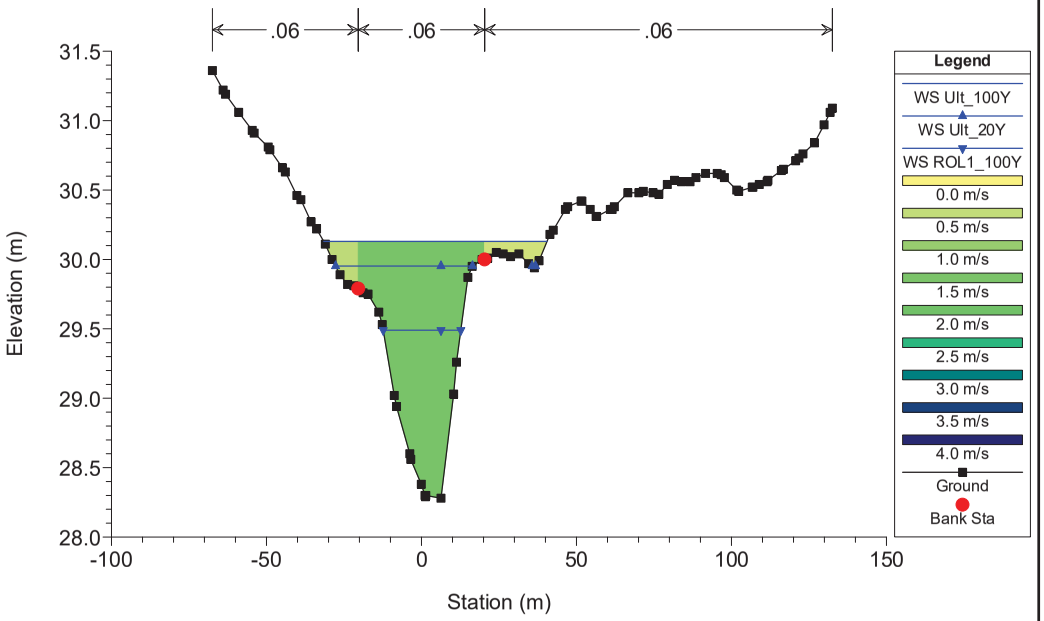


Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1989



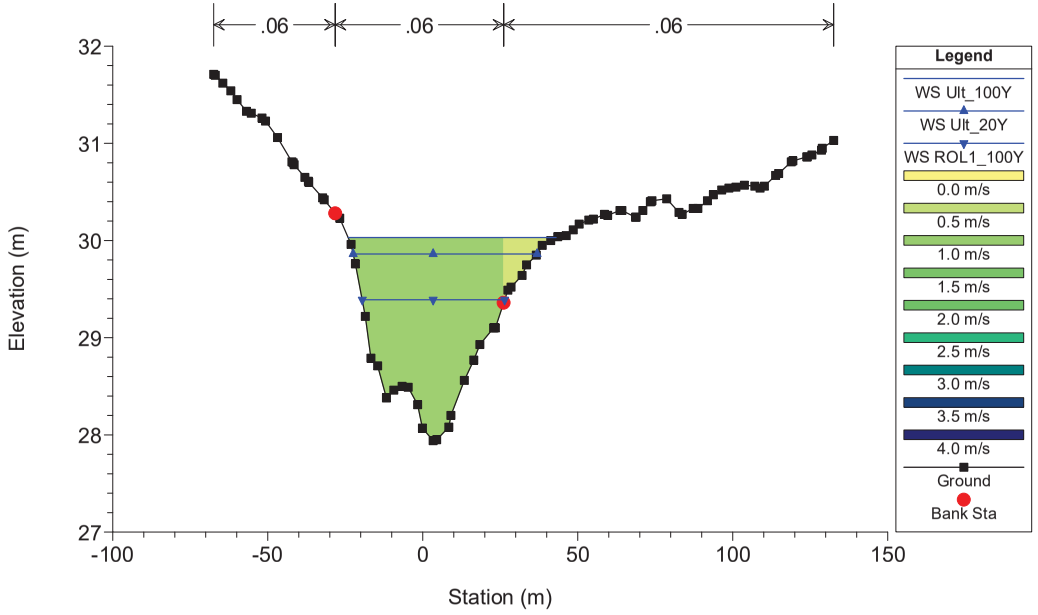
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1848



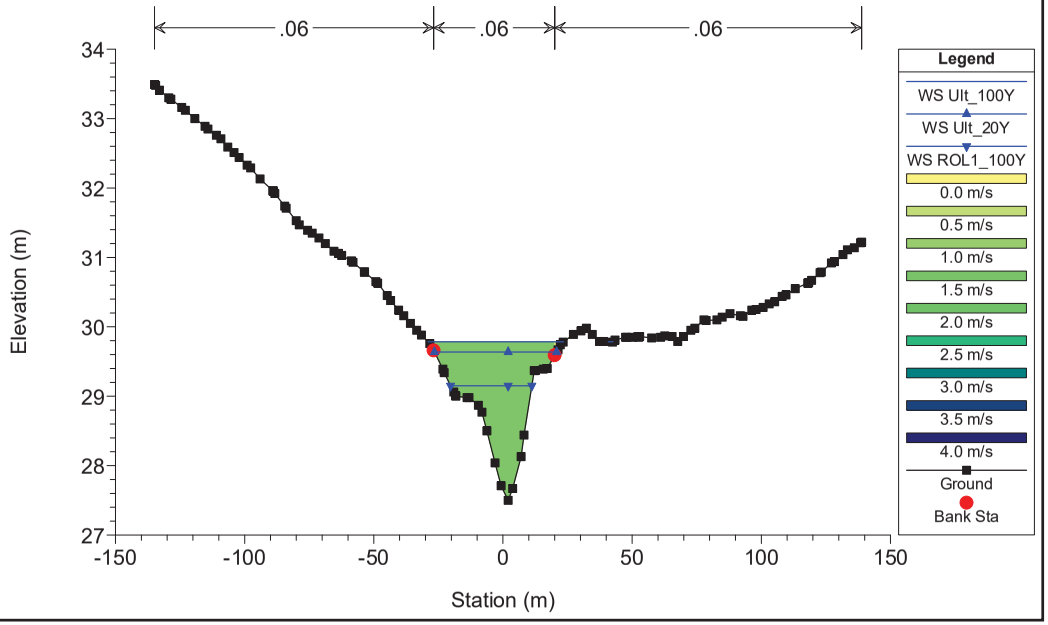
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1806



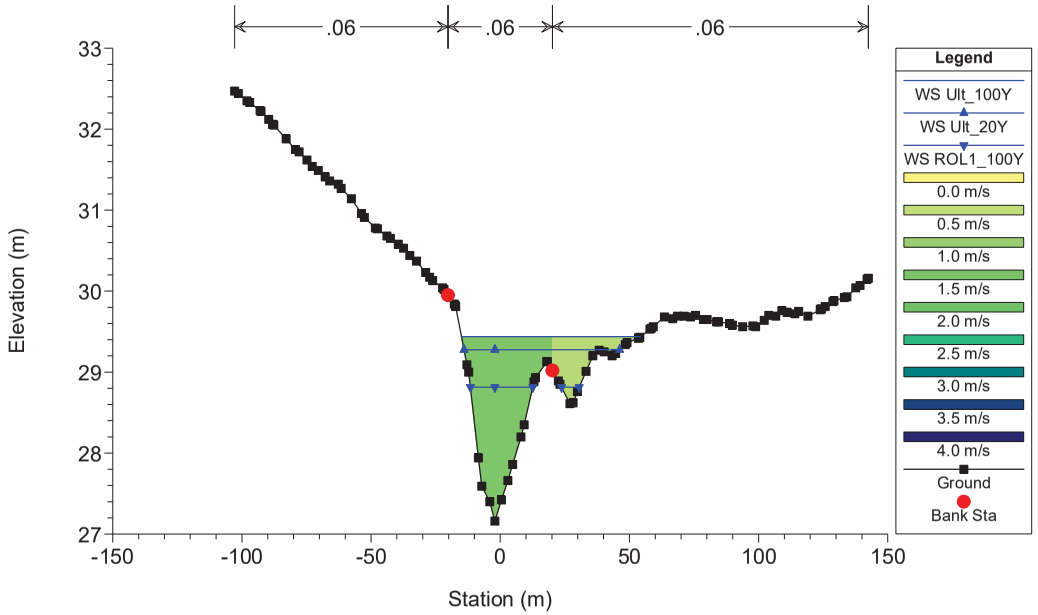
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1748



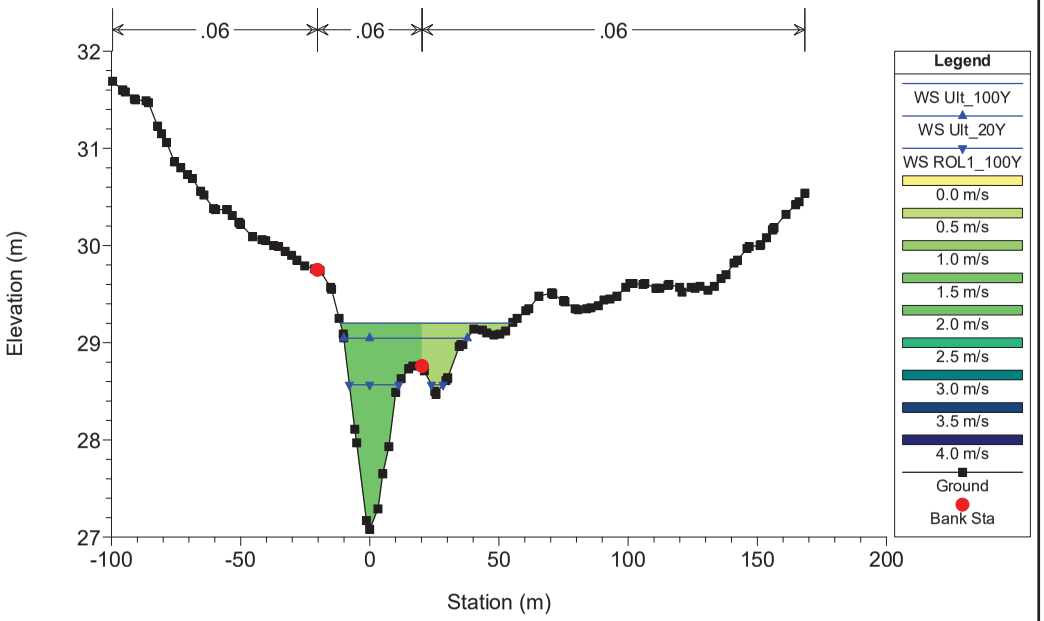
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1687



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1662



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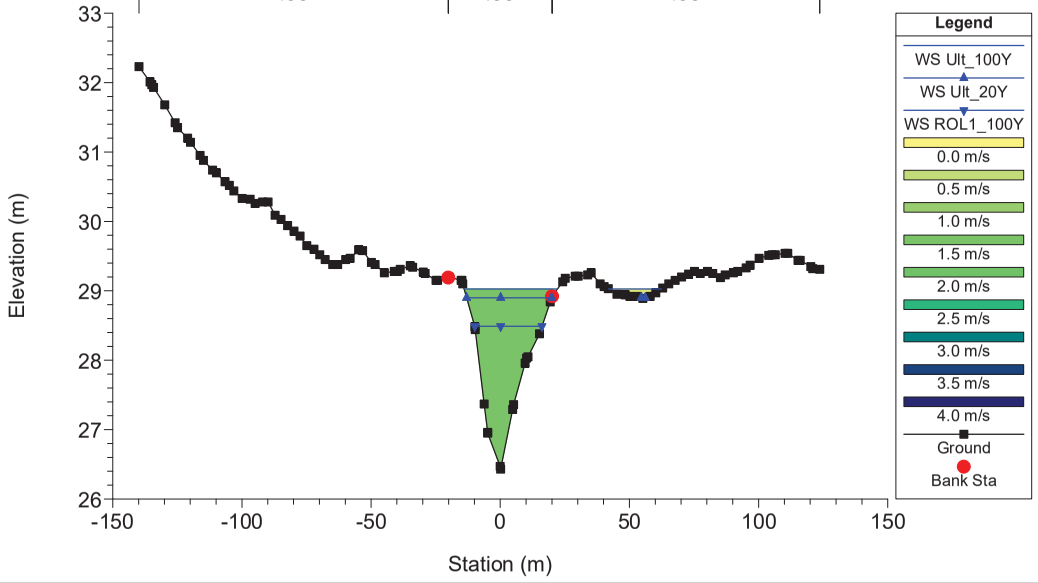
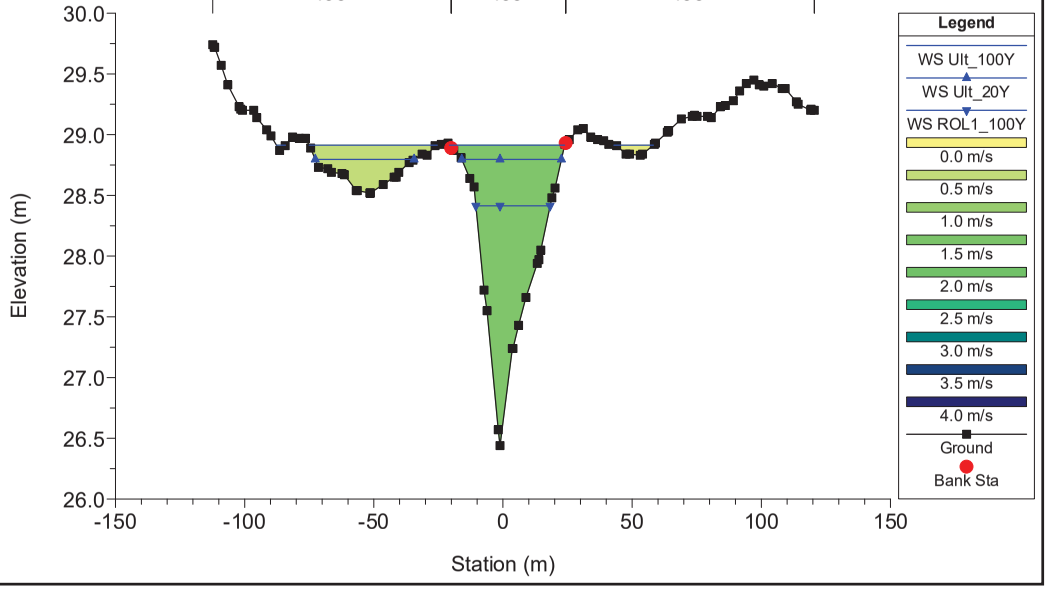
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1638



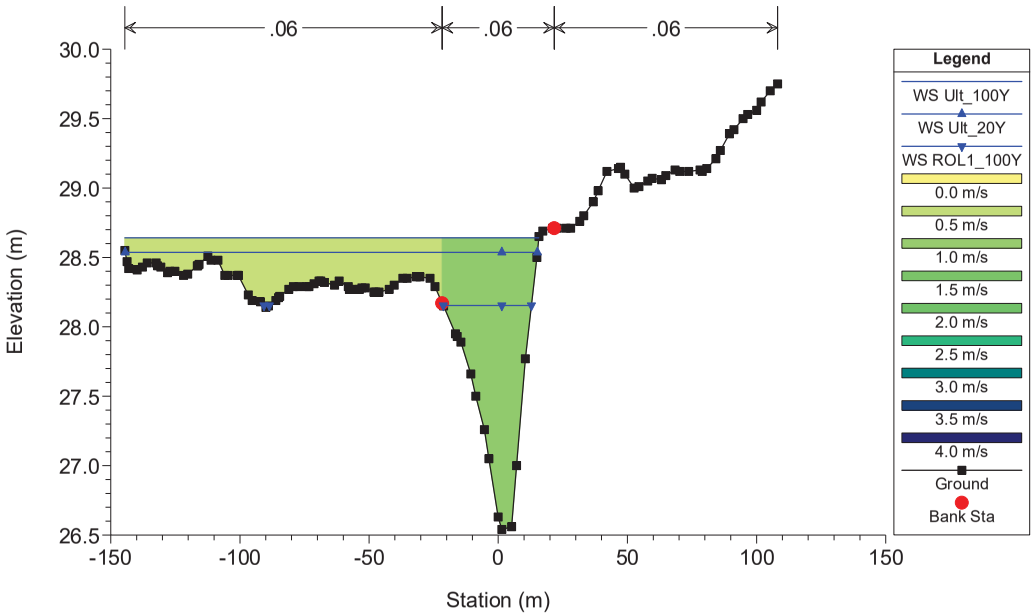
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1618



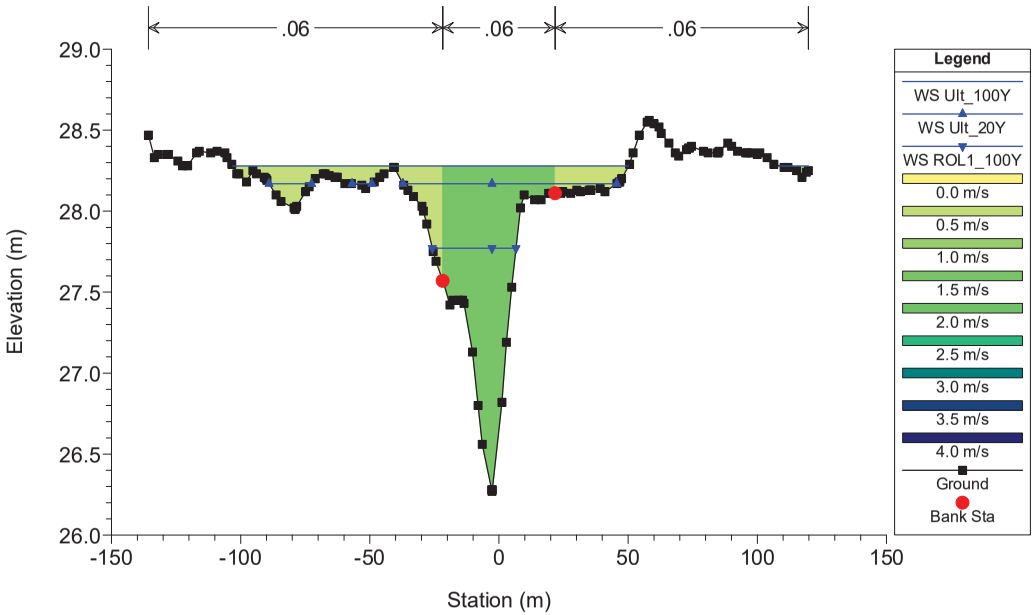
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1554



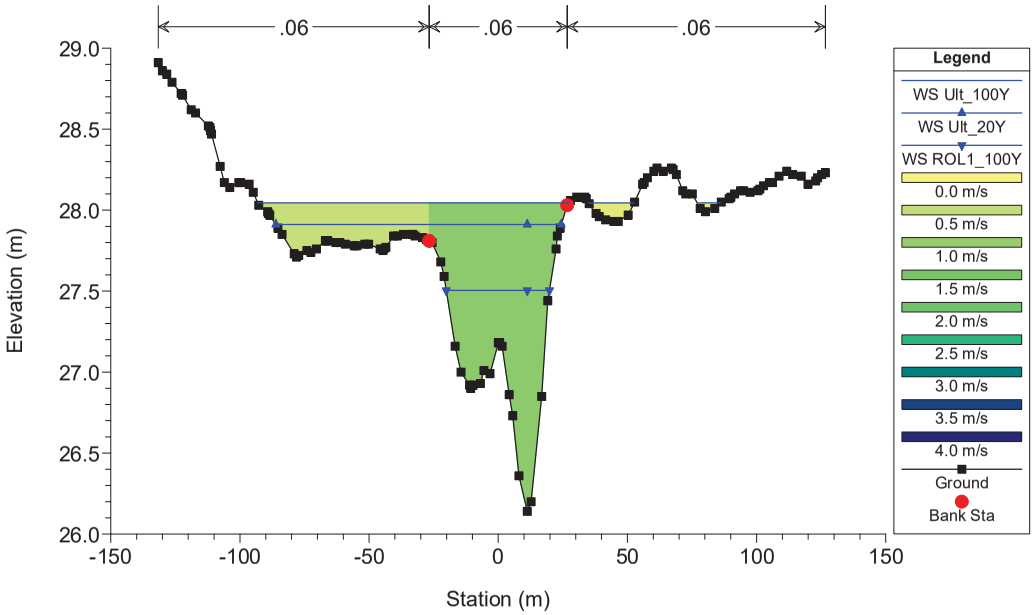
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1497



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1460



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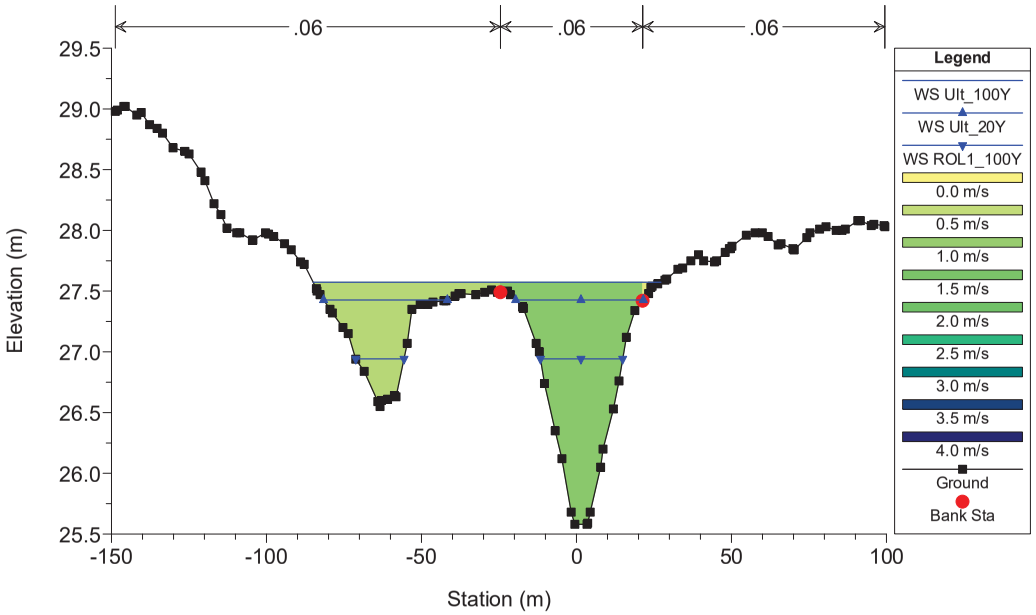
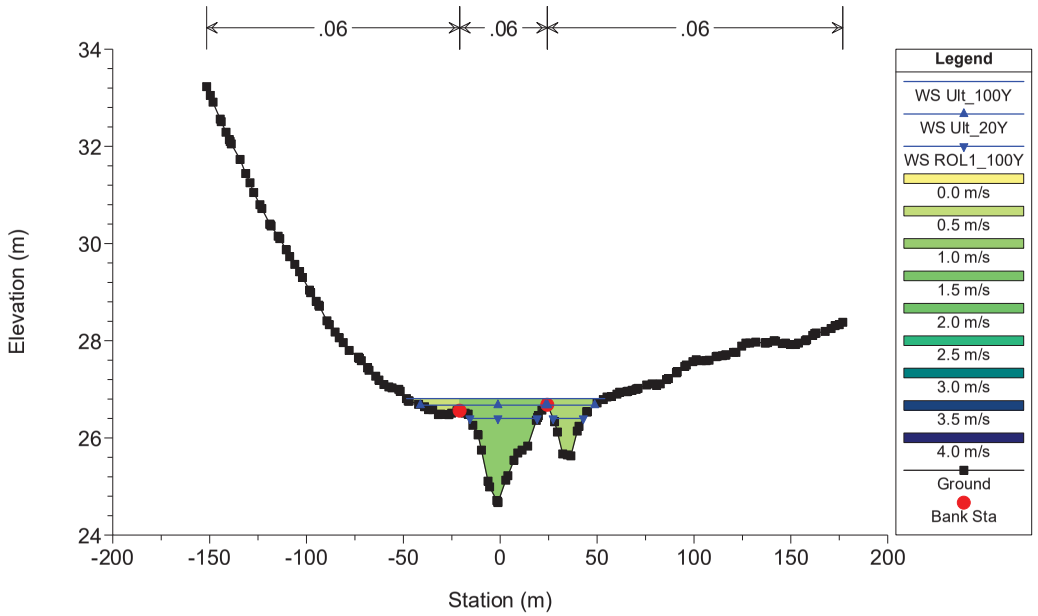
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1370



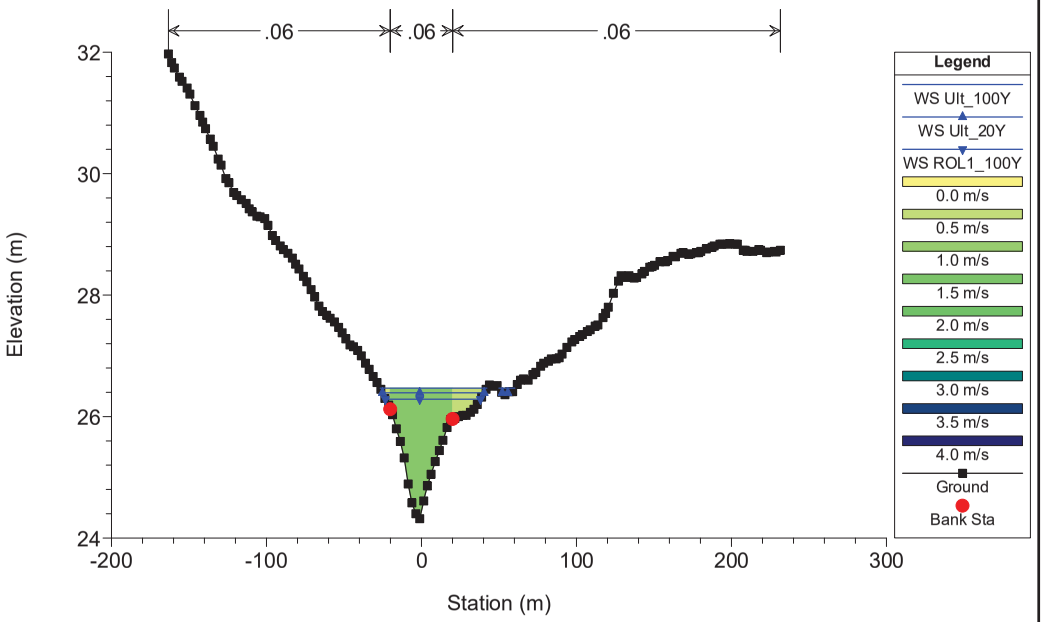
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1209



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 - n006 20/06/2017 2:47:44 PM

Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1129



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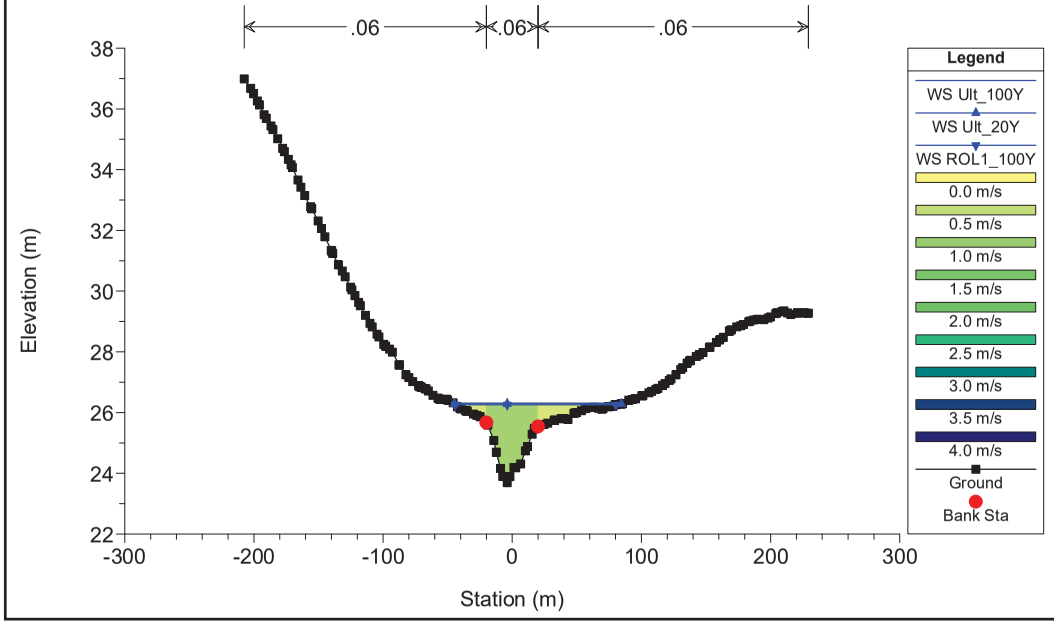
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 1040



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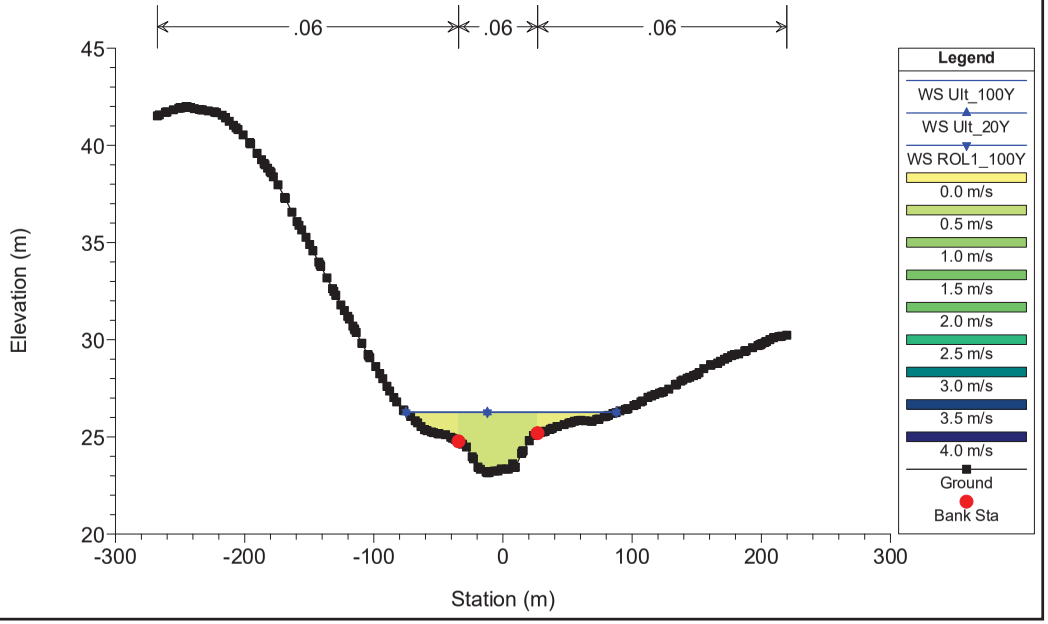
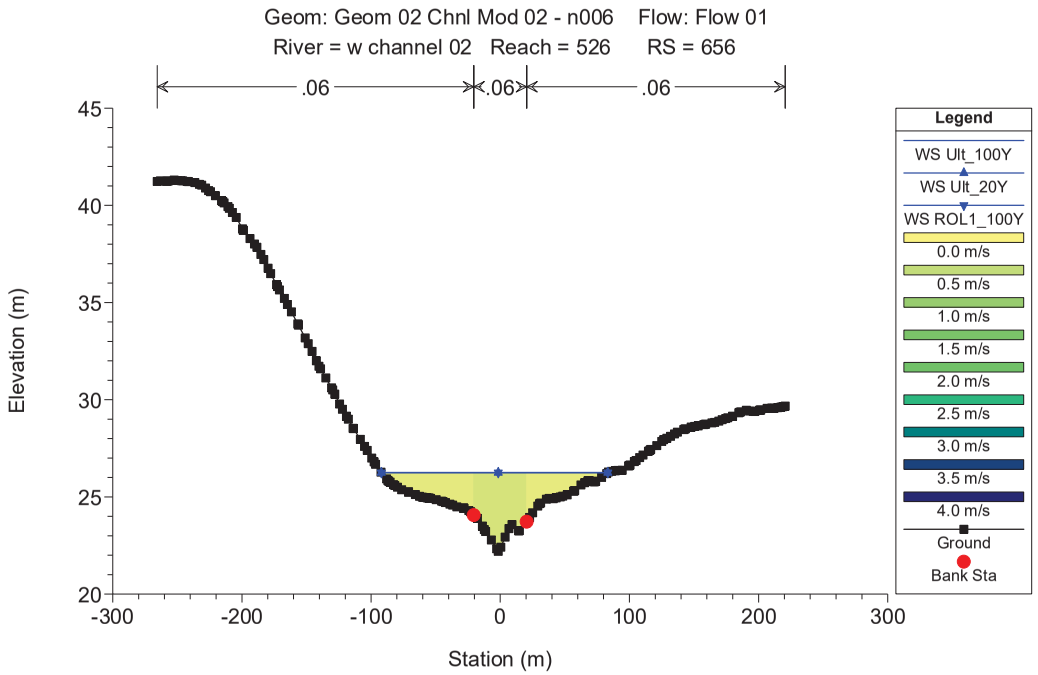
Geom: Geom 02 Chnl Mod 02 - n006 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 864





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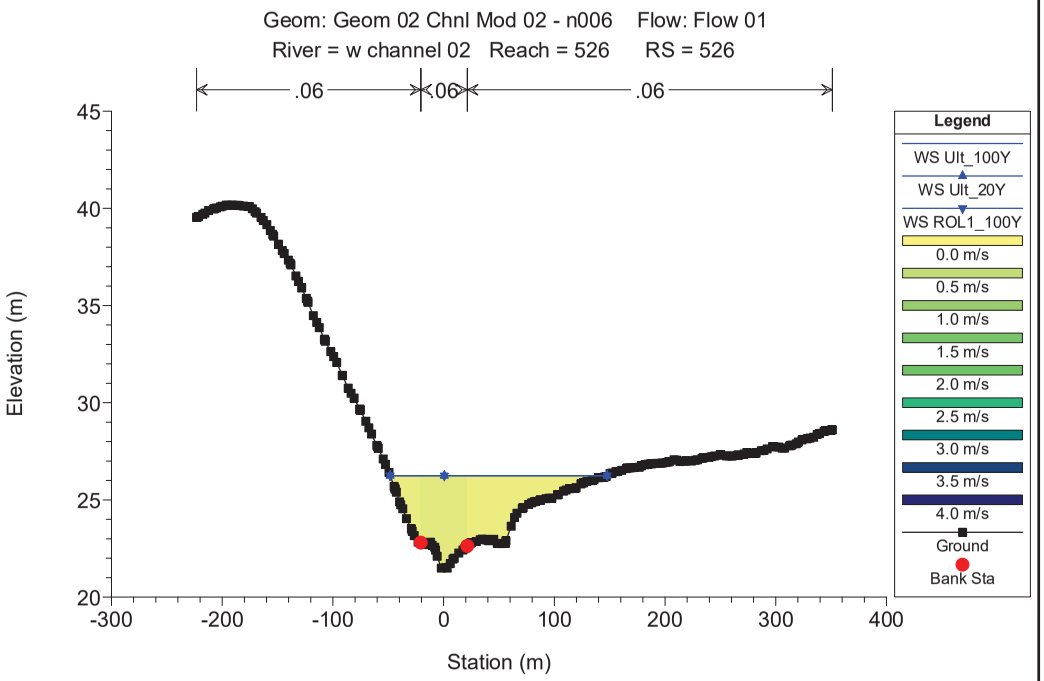

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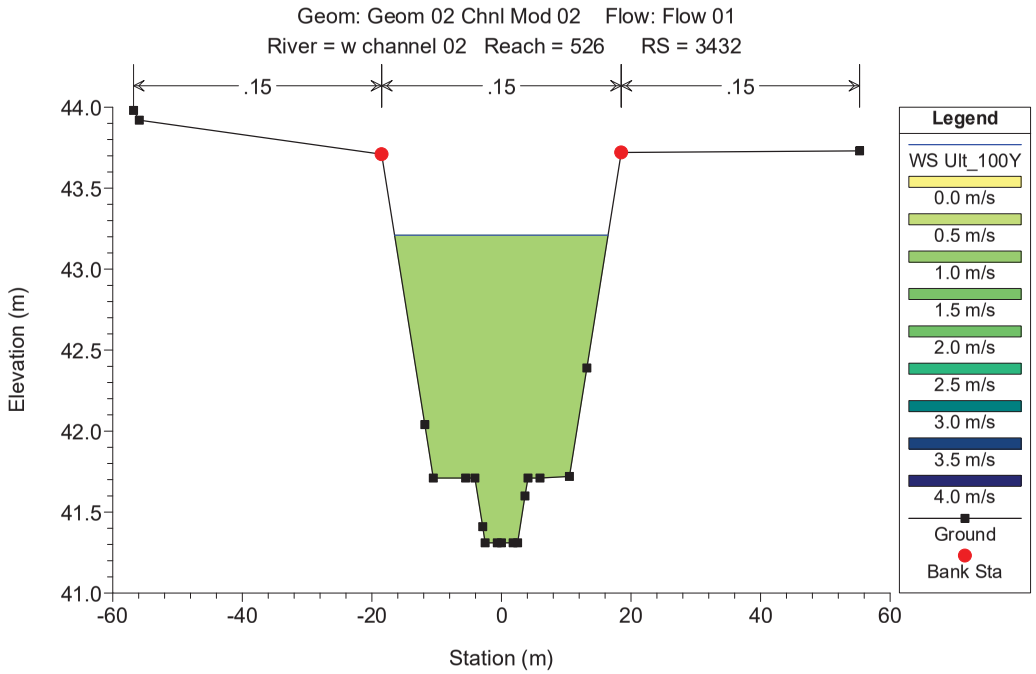

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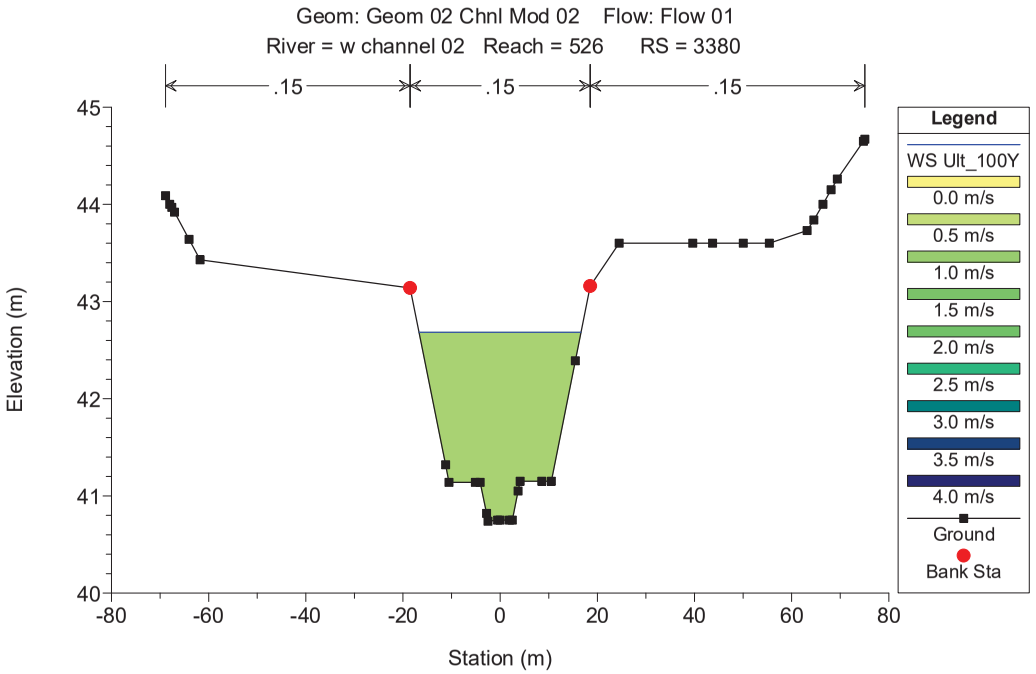

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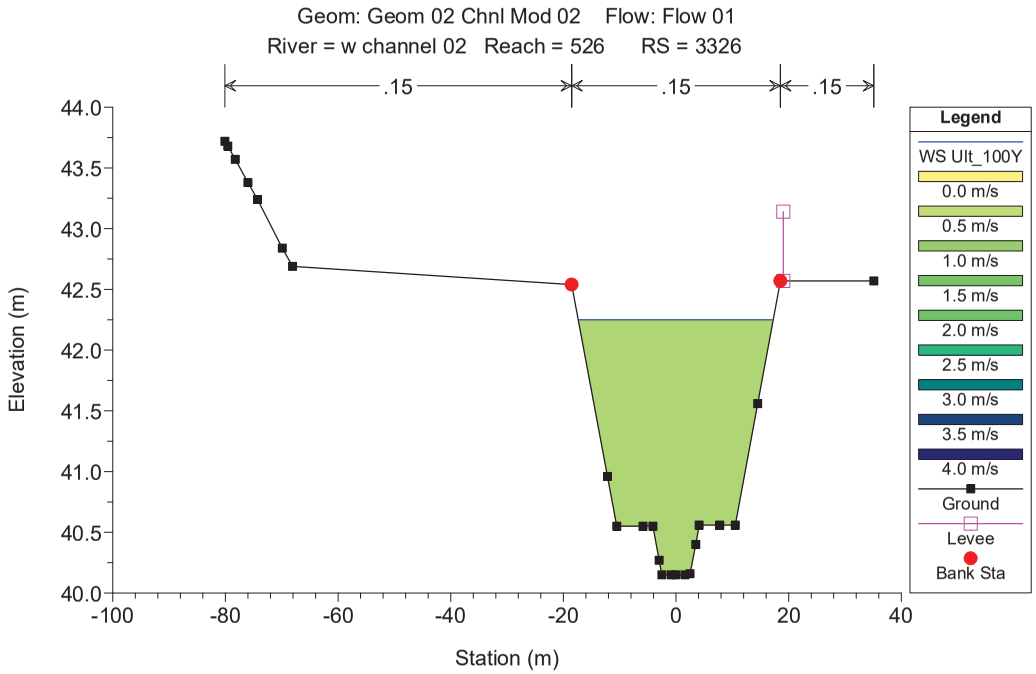

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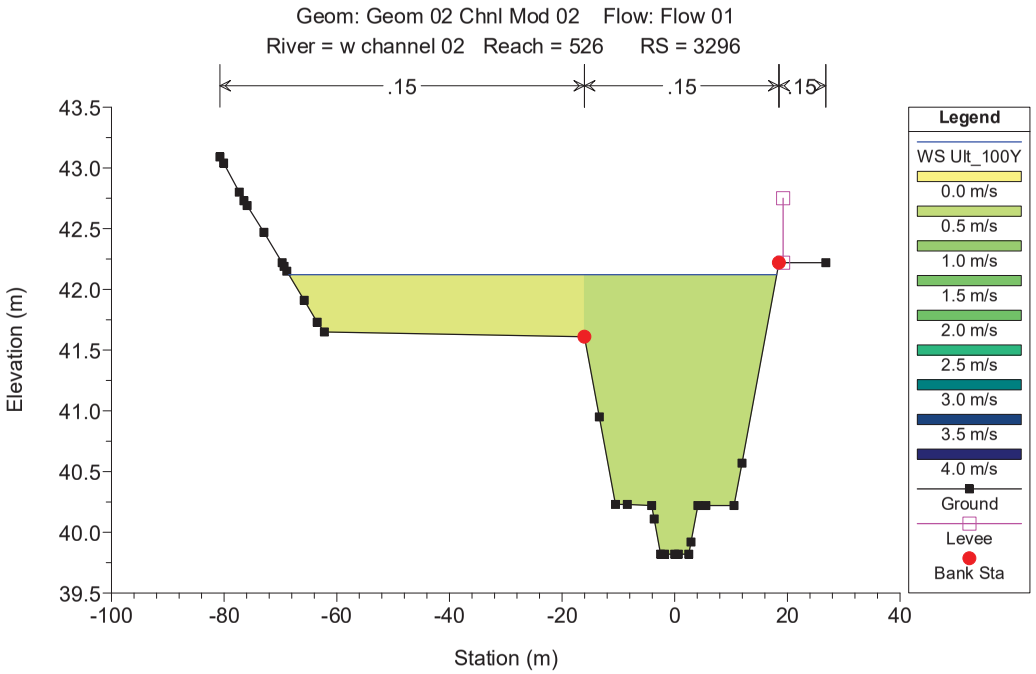
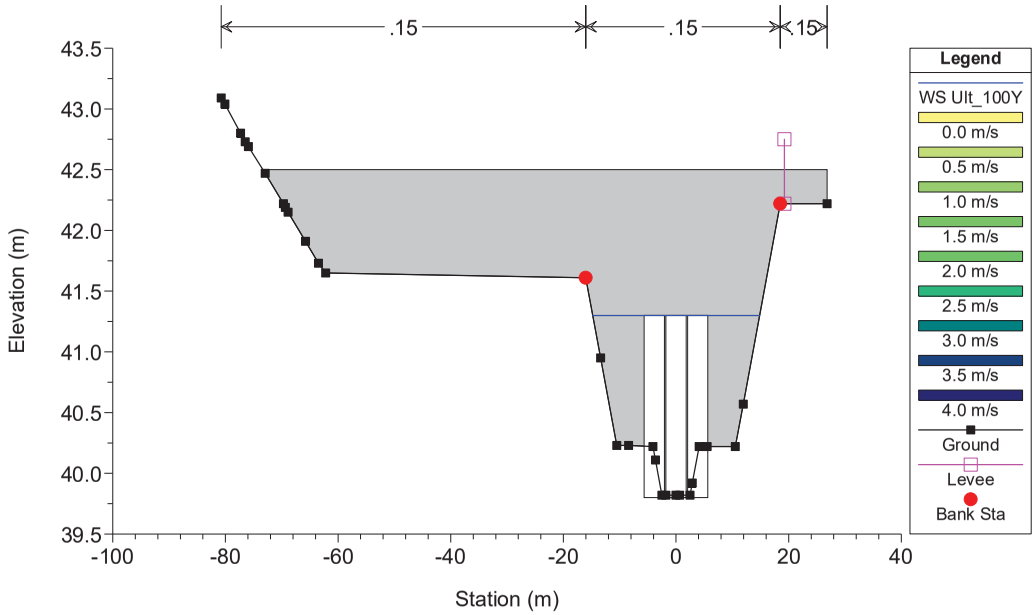


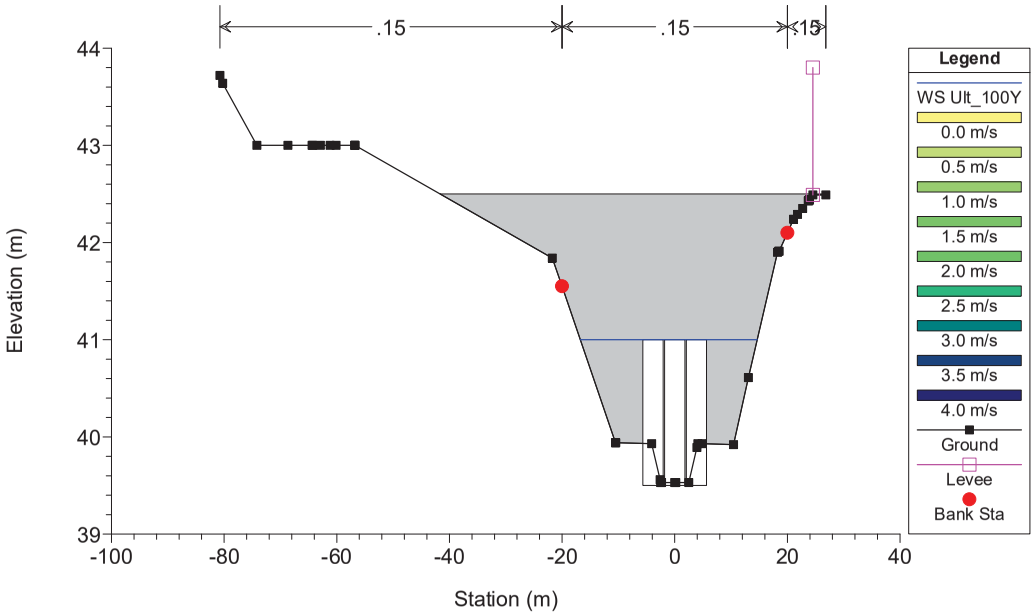
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3282.5 Culv



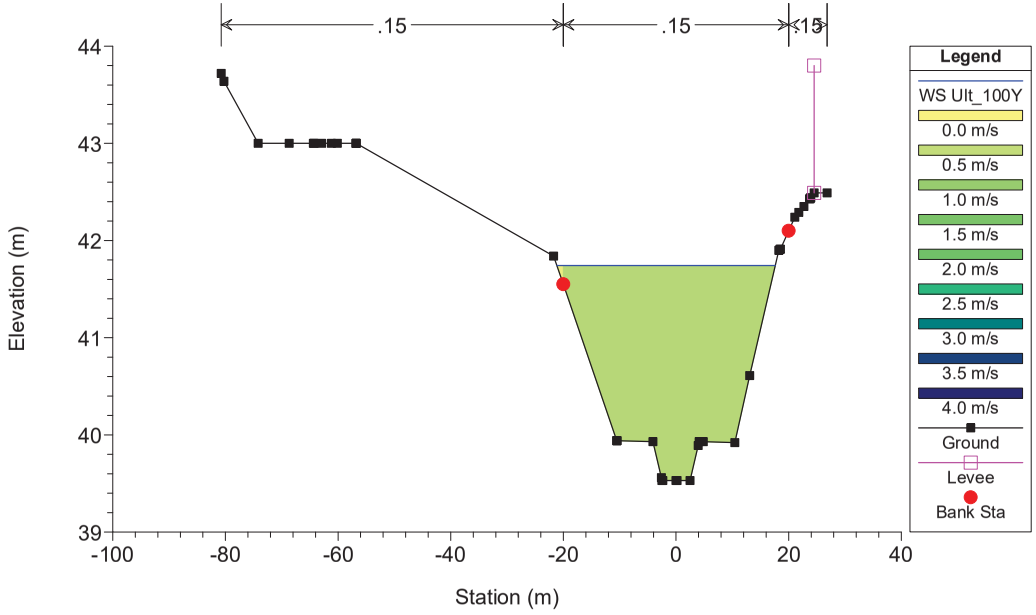
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3282.5 Culv



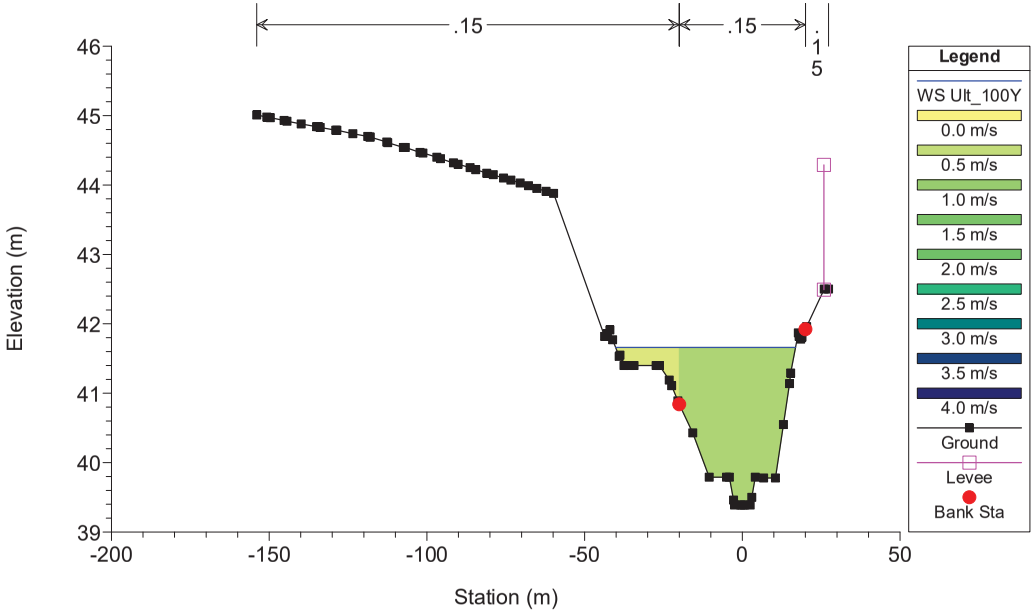
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3269



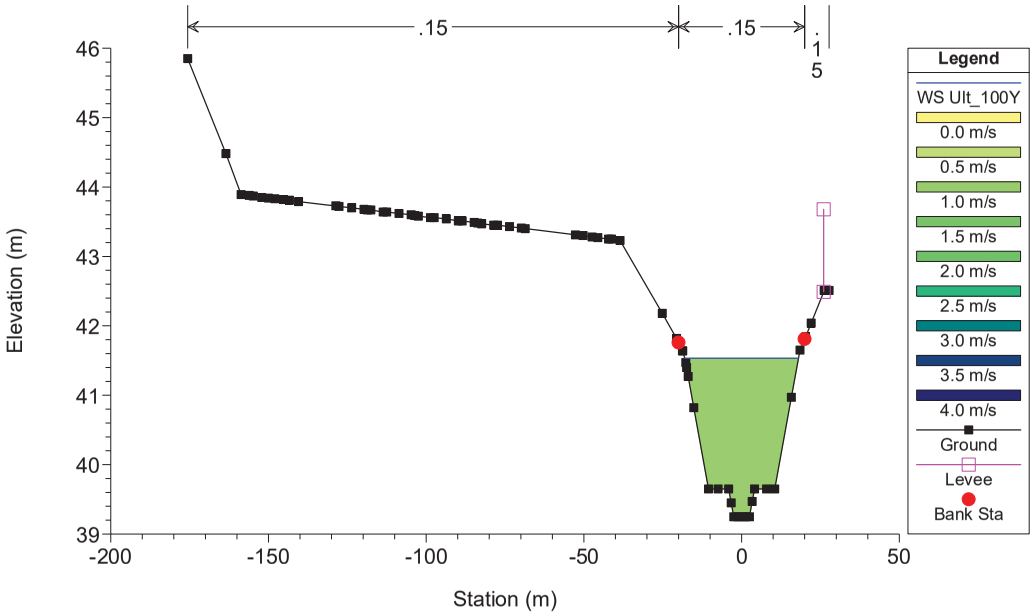
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3255



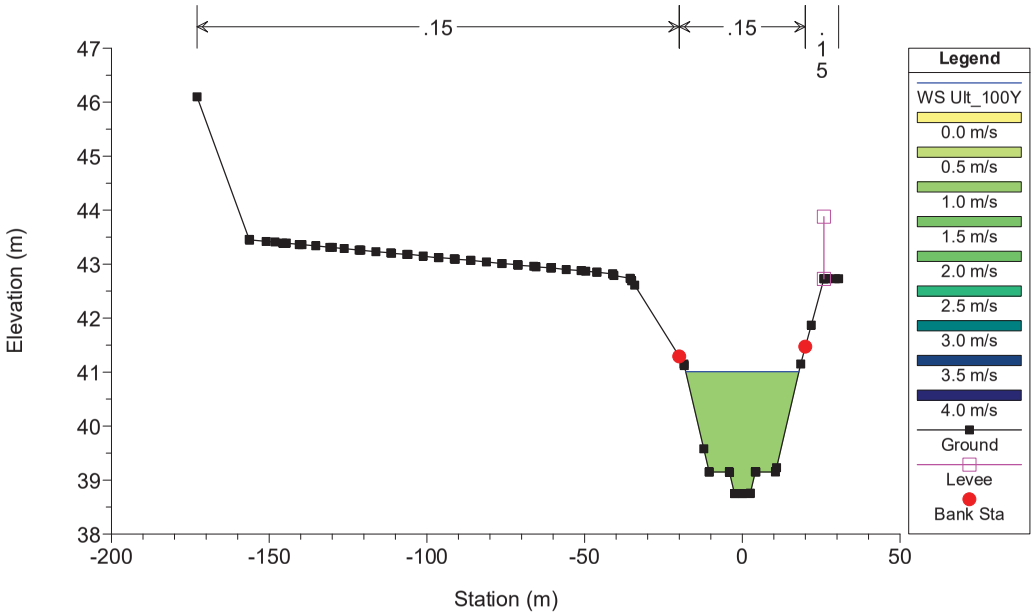
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3243



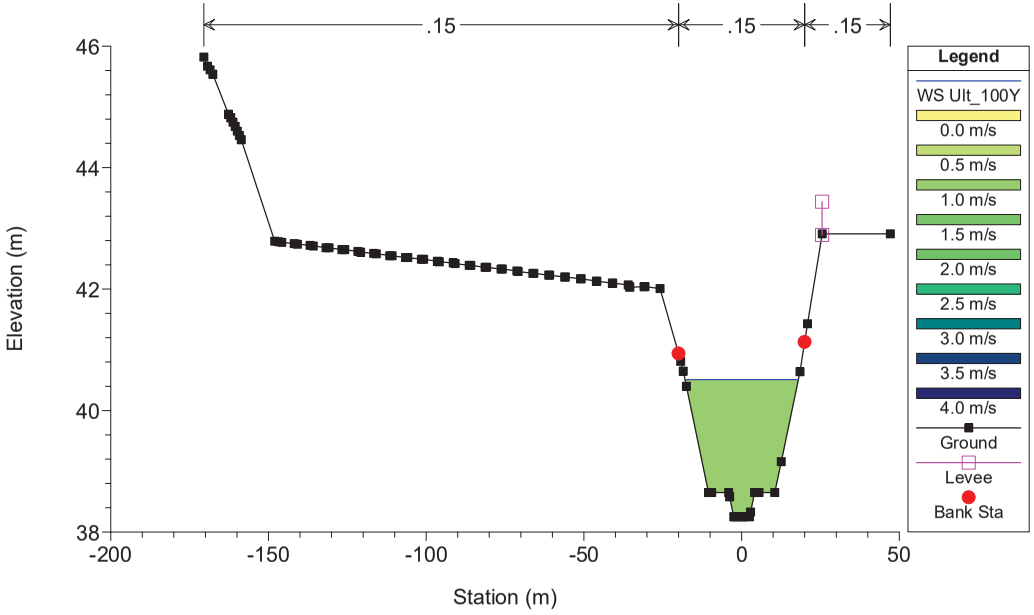
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3199



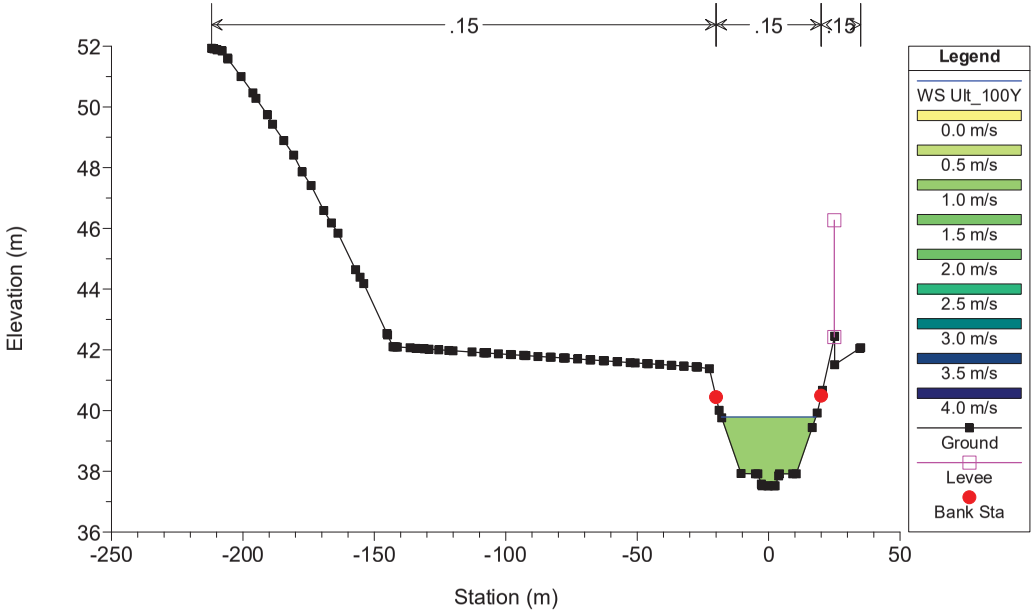
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3158



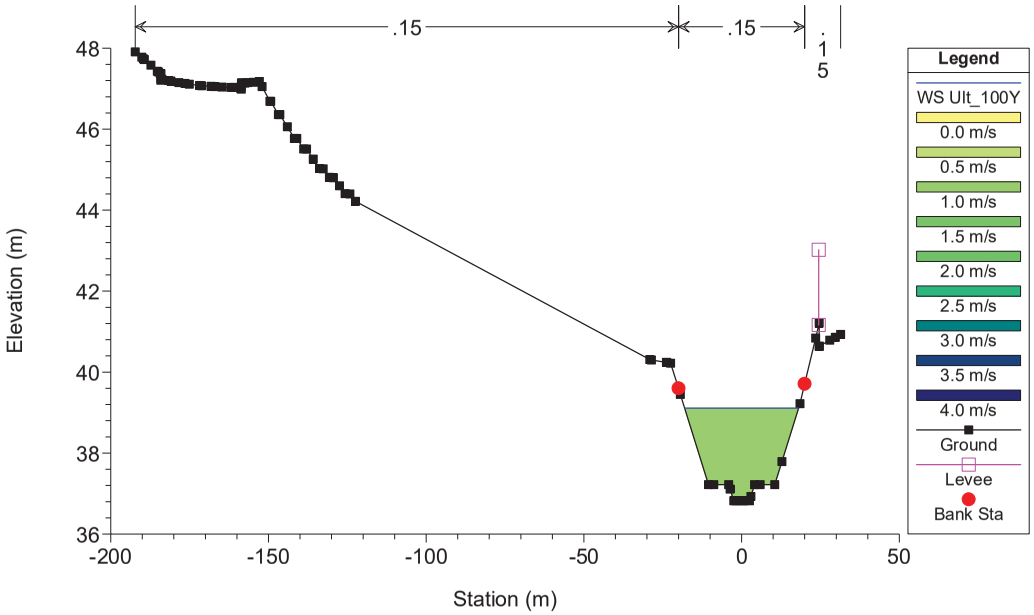
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3098



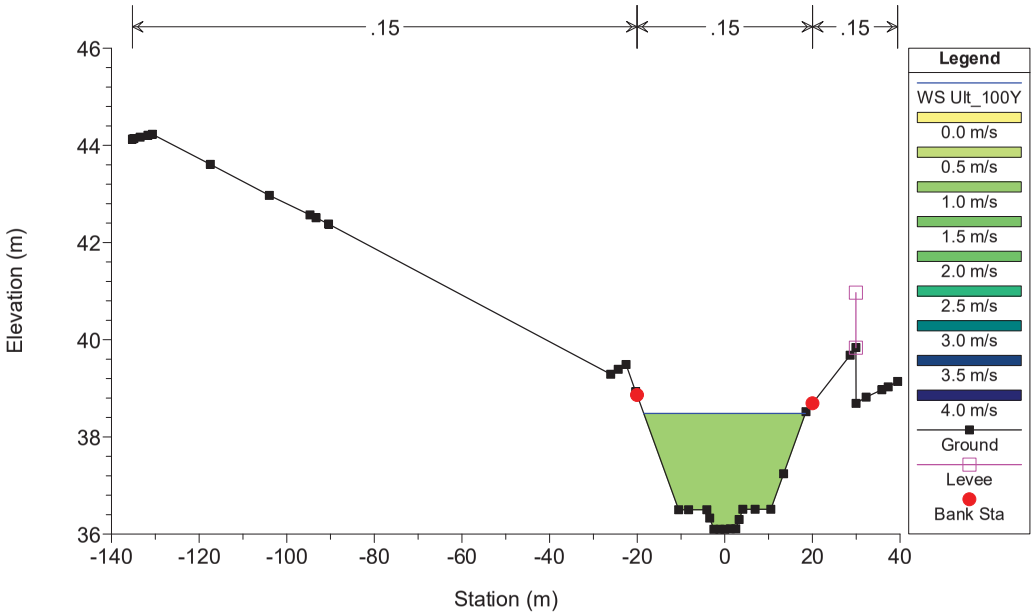
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 3041



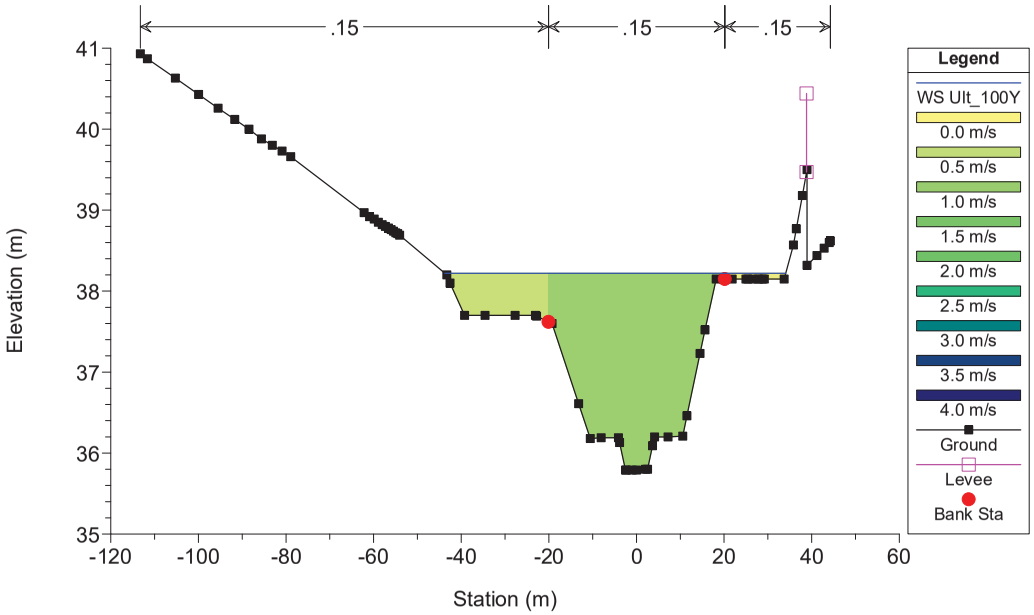
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2982



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2956



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
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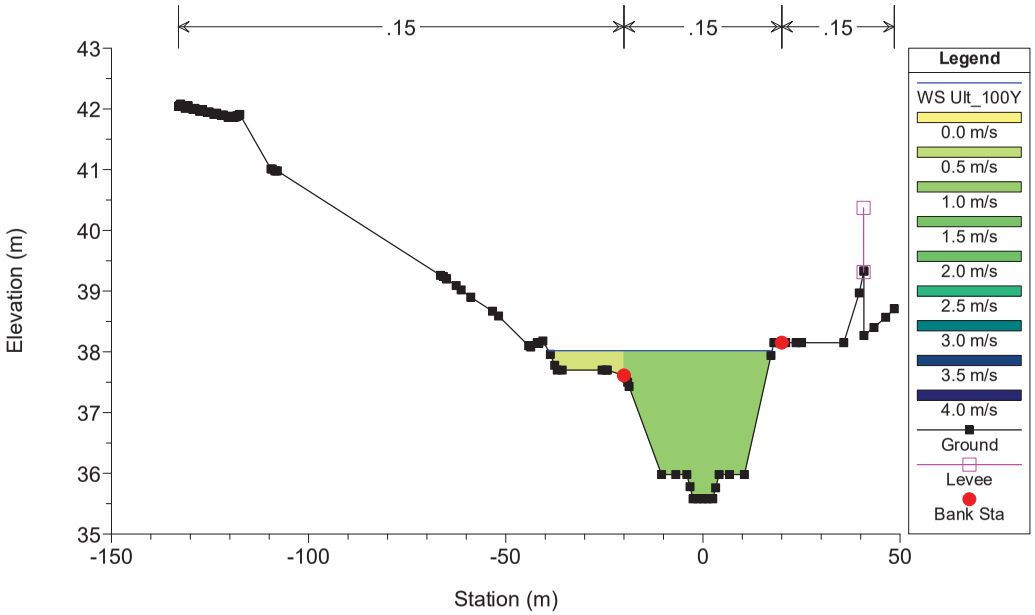
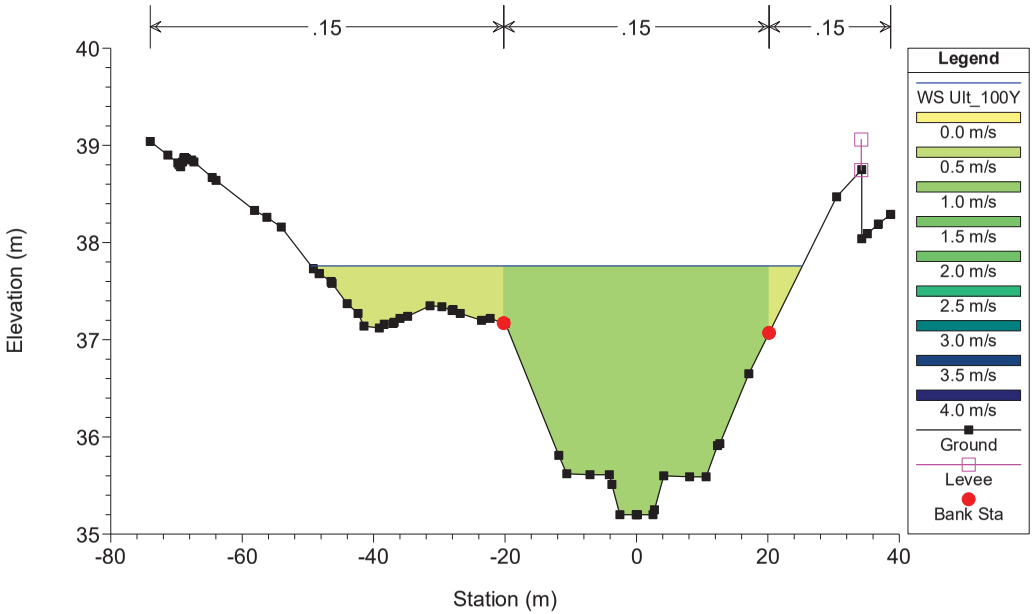


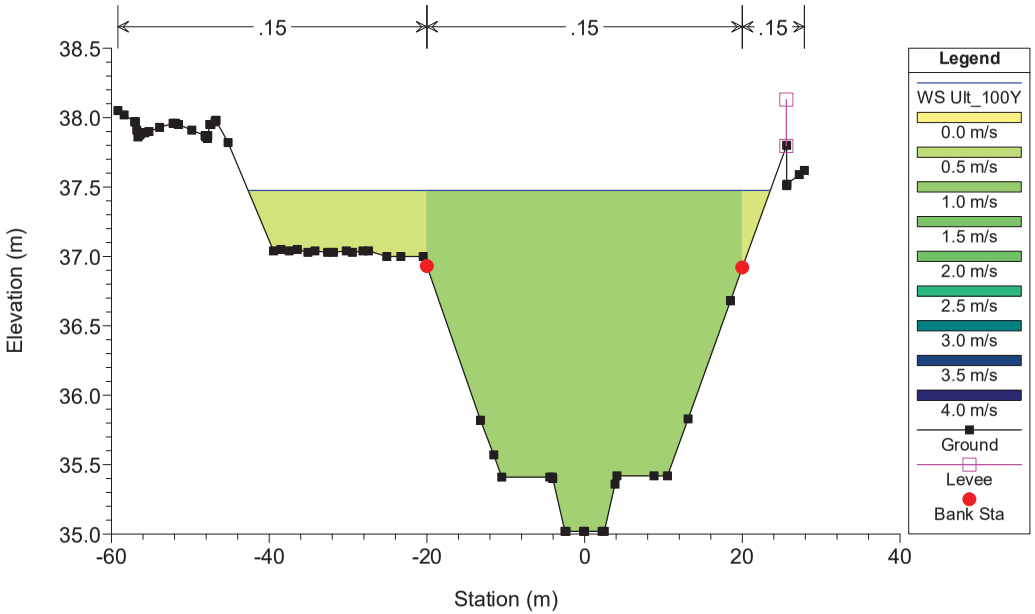
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2907



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2870



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
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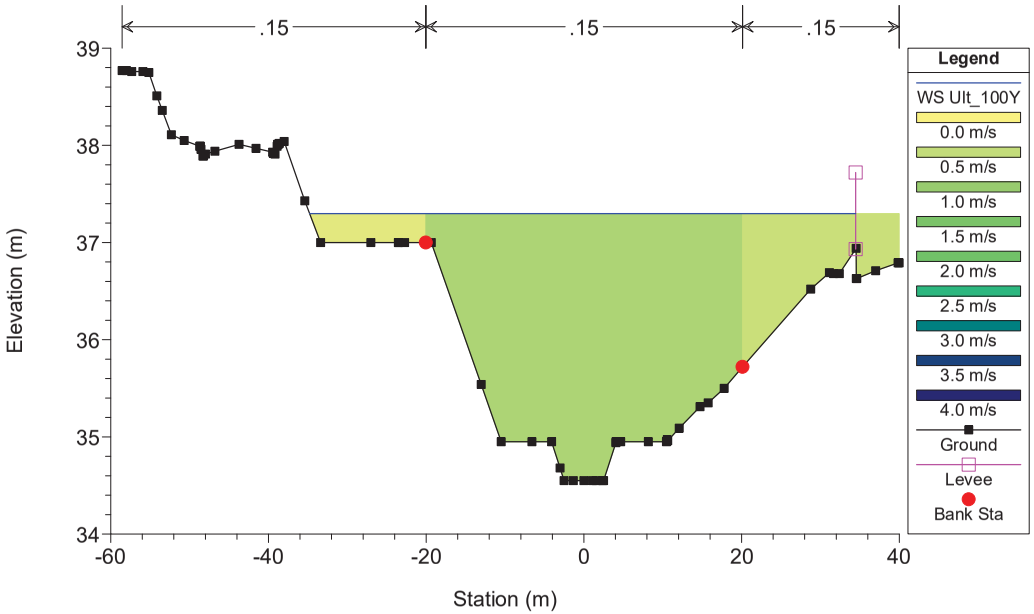
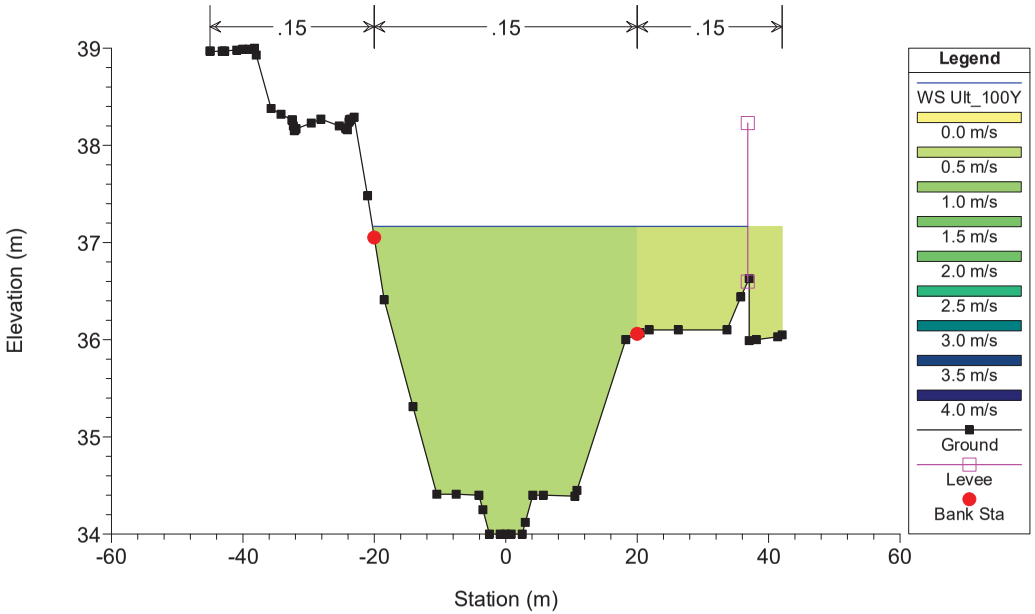


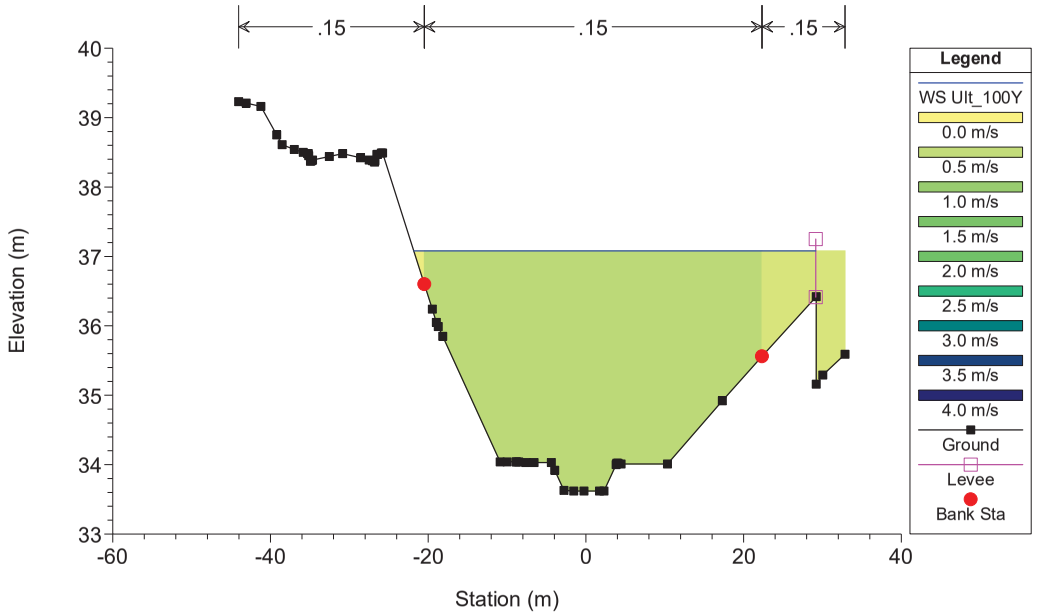
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2803



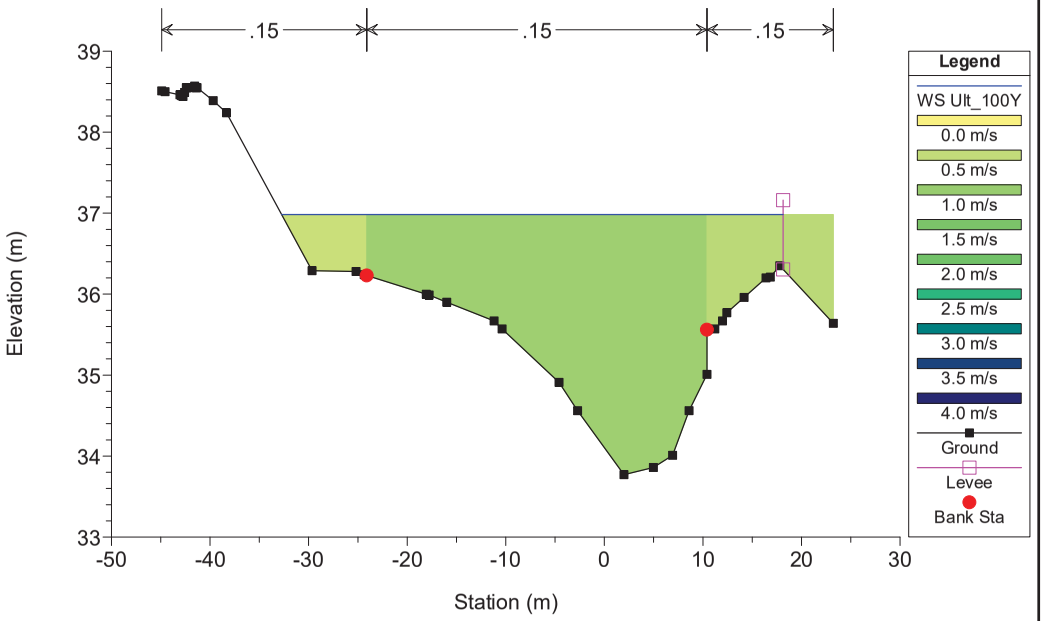
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2766



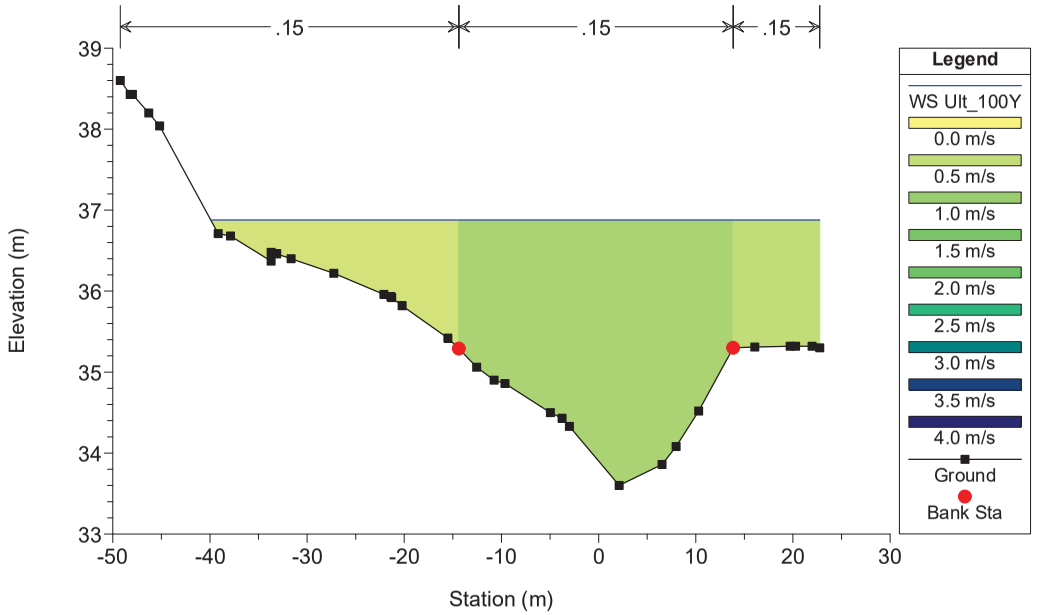
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2747



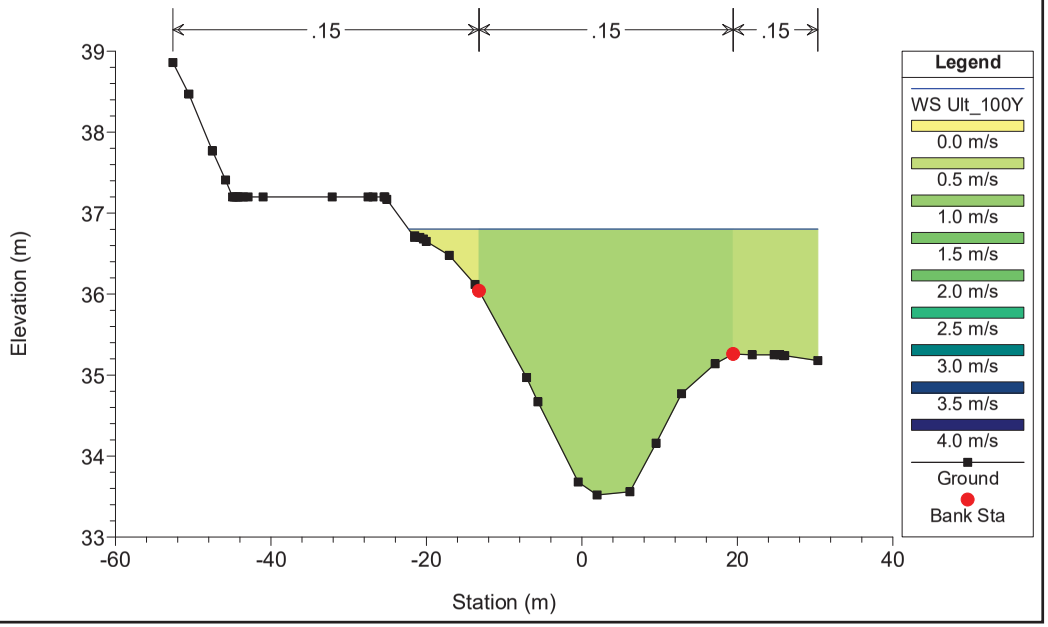
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2726

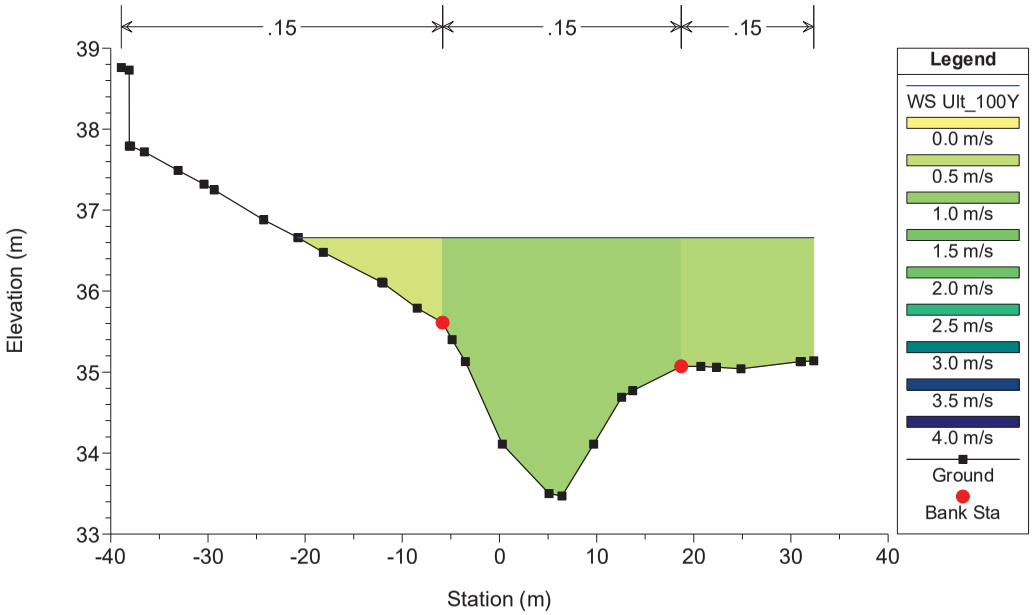


\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2707

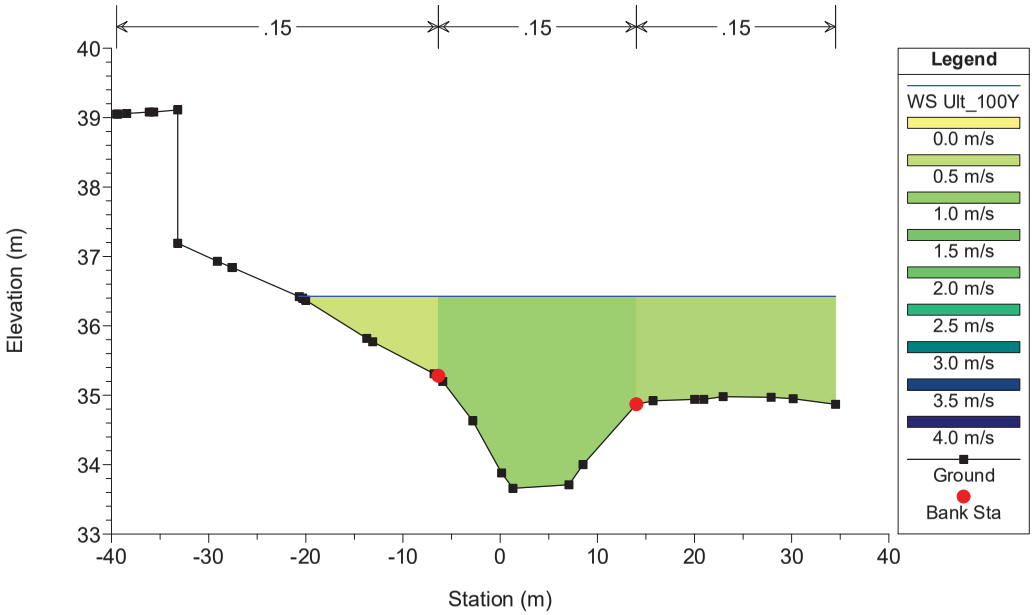


Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2681



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2645



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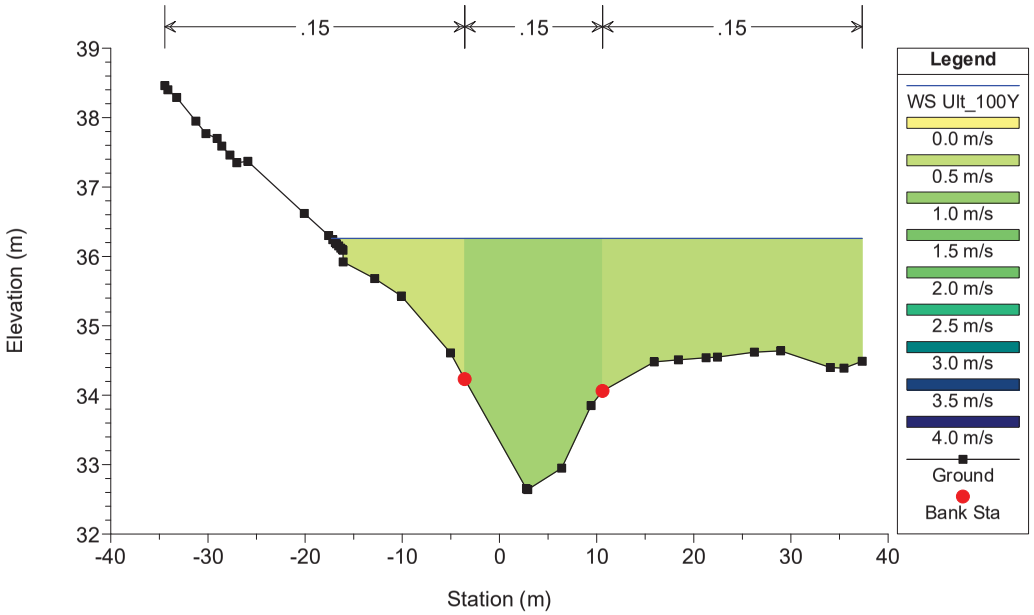
Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2611



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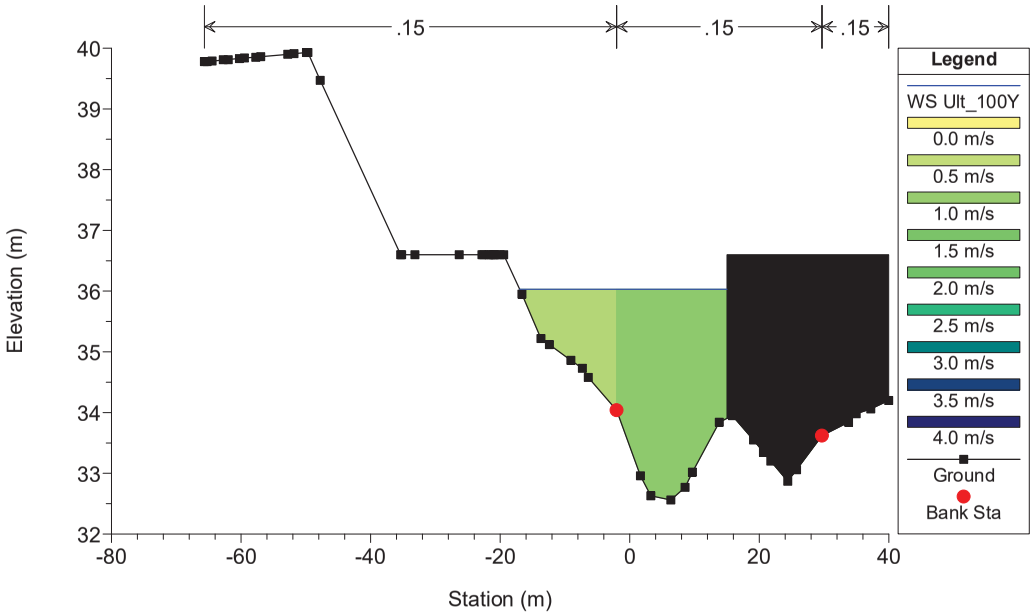
Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2575



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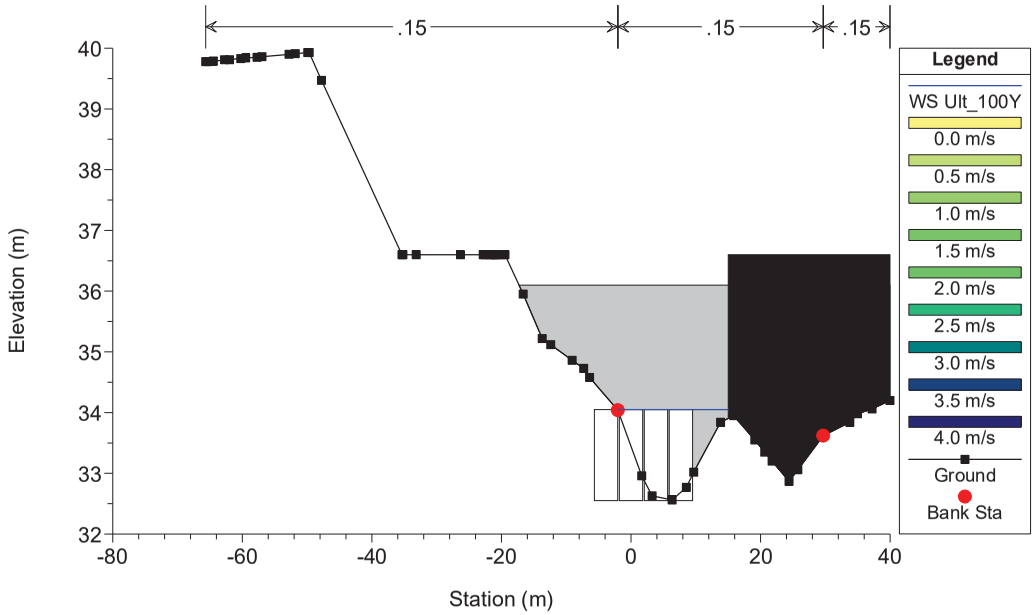
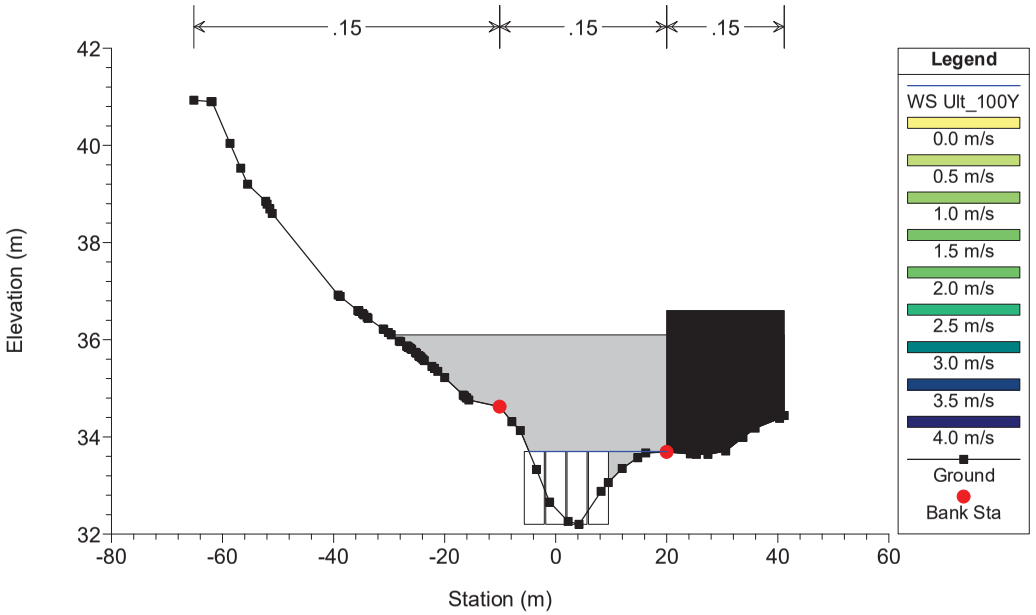
Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2553 Culv



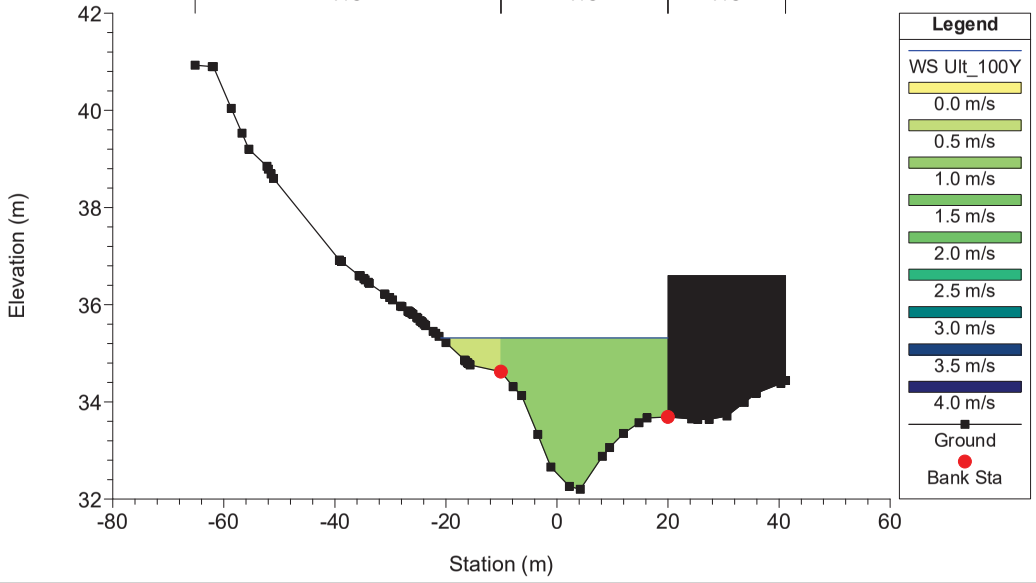
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2553 Culv



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2531



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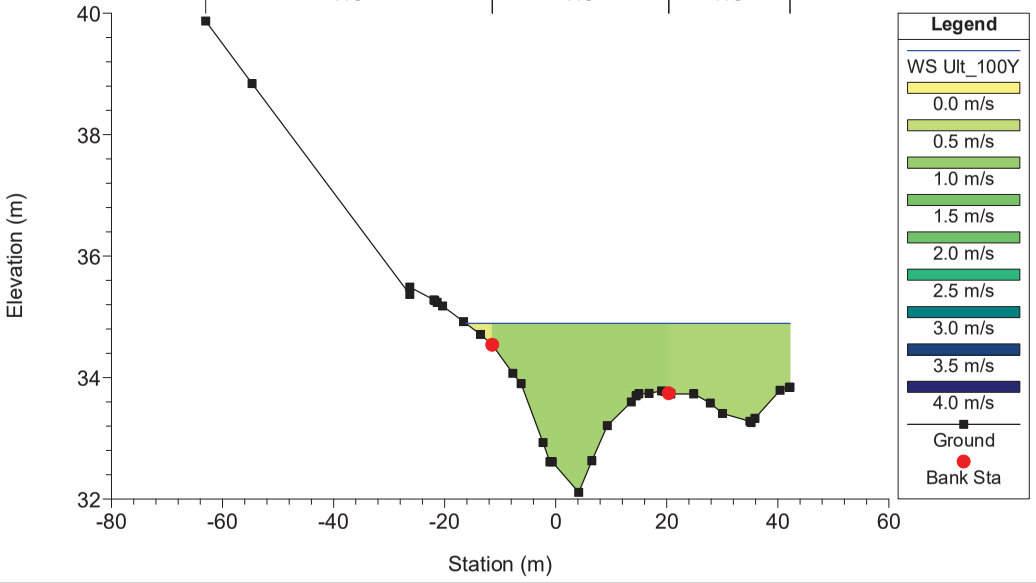
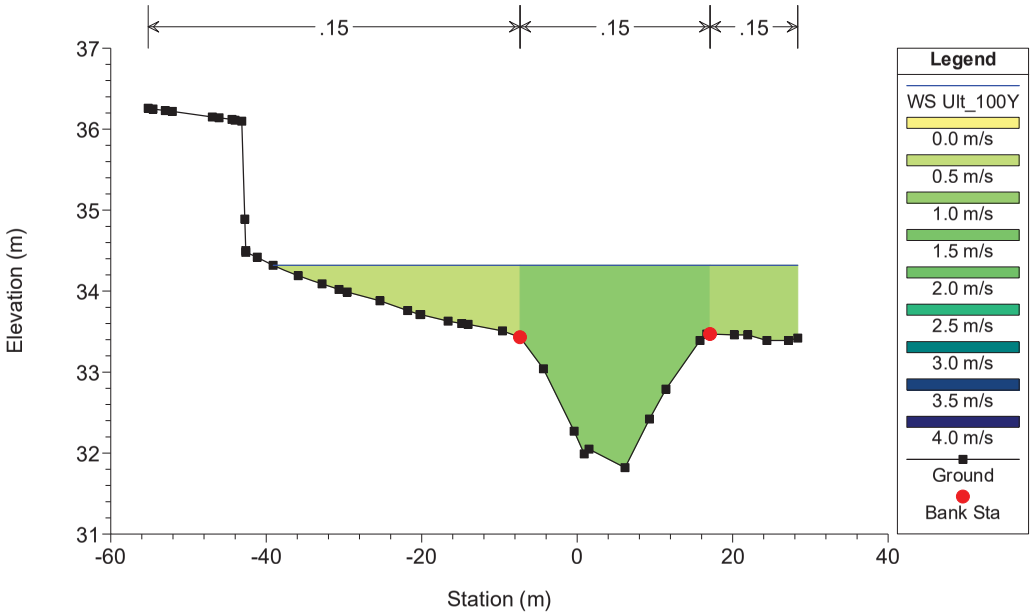
Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2483



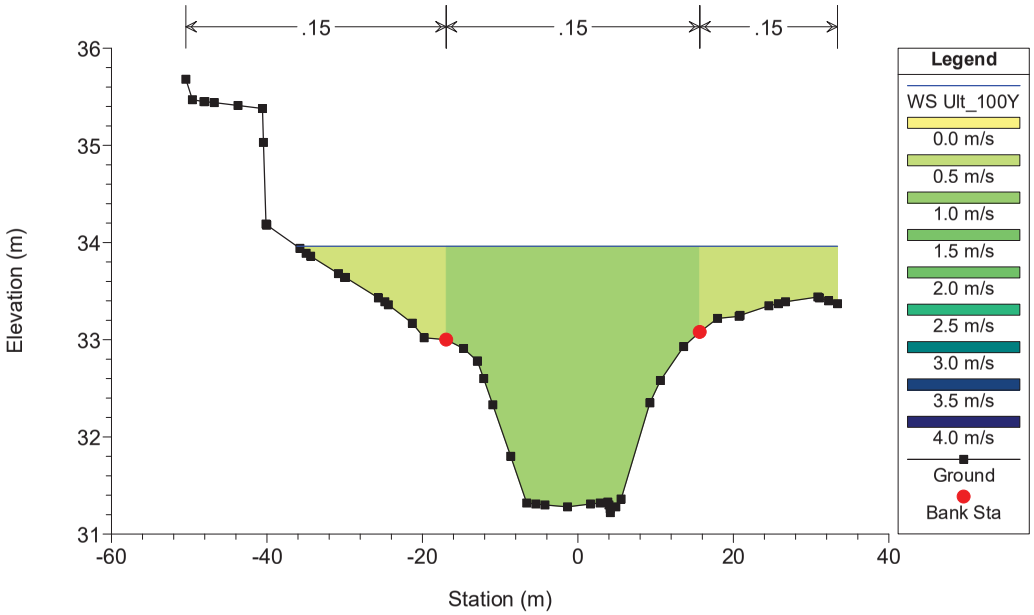
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2431



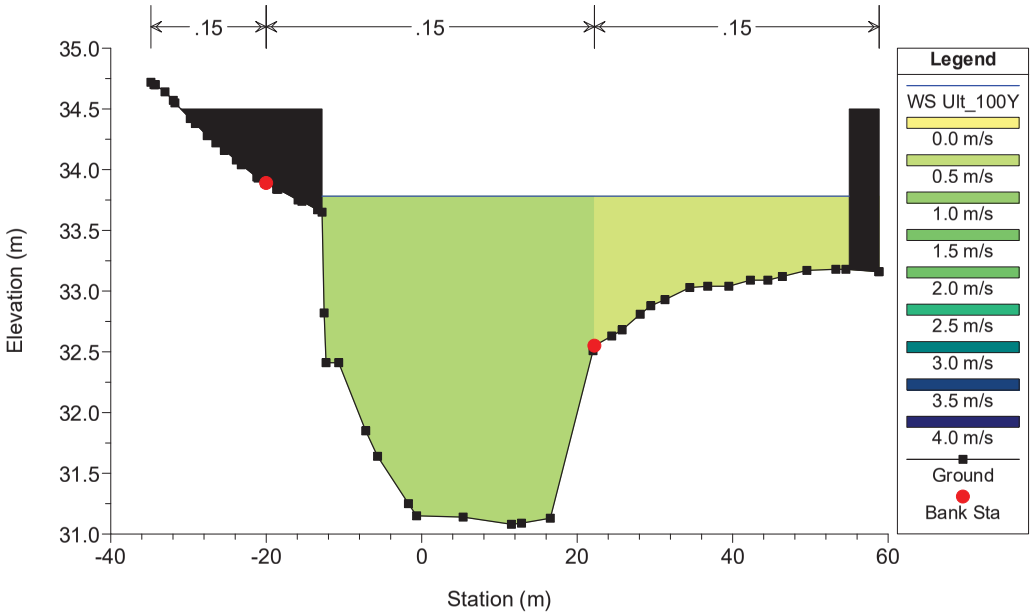
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2392



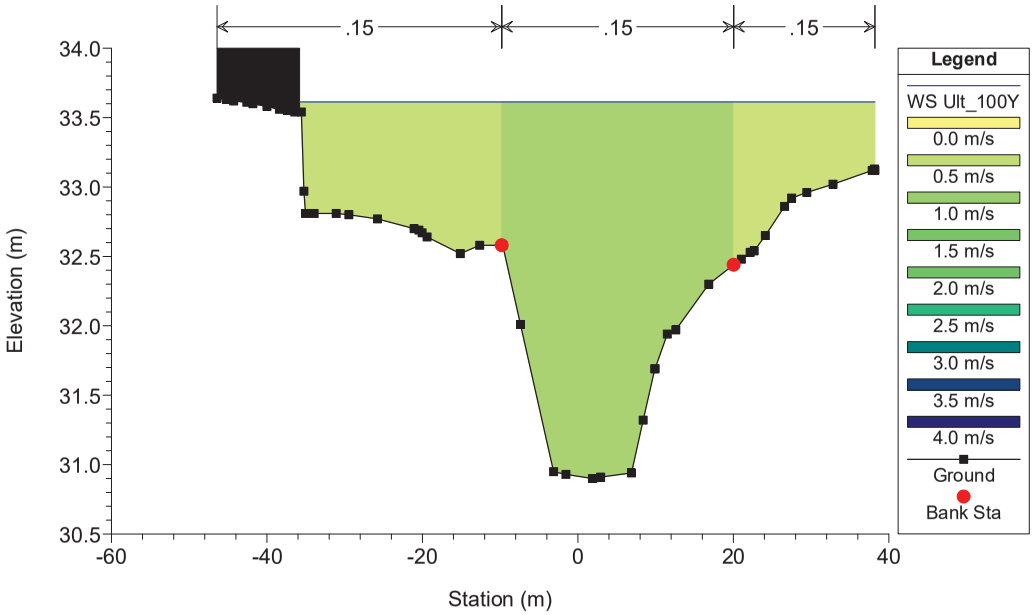
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2352



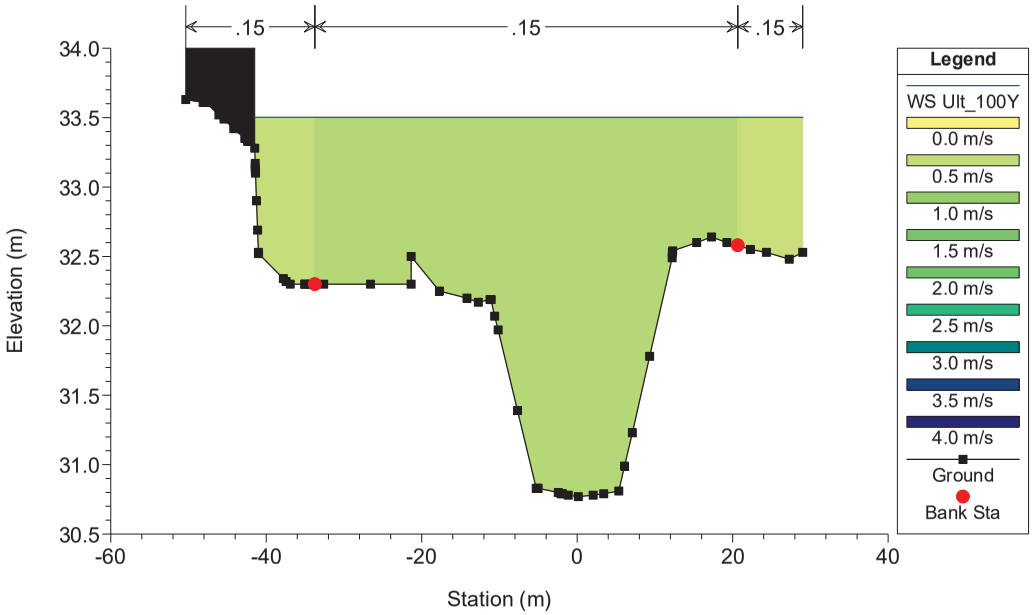
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2312



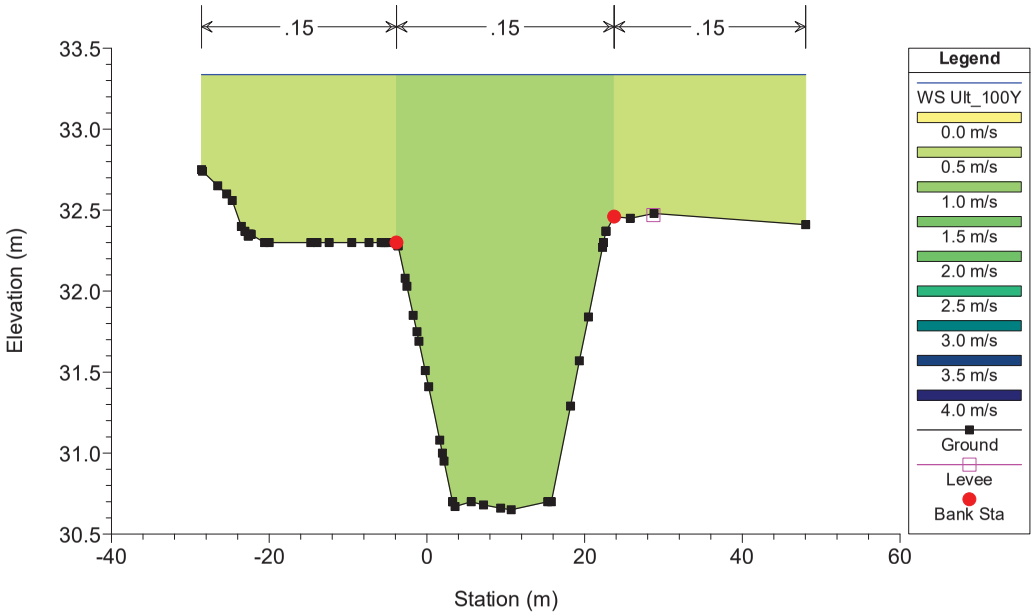
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2290



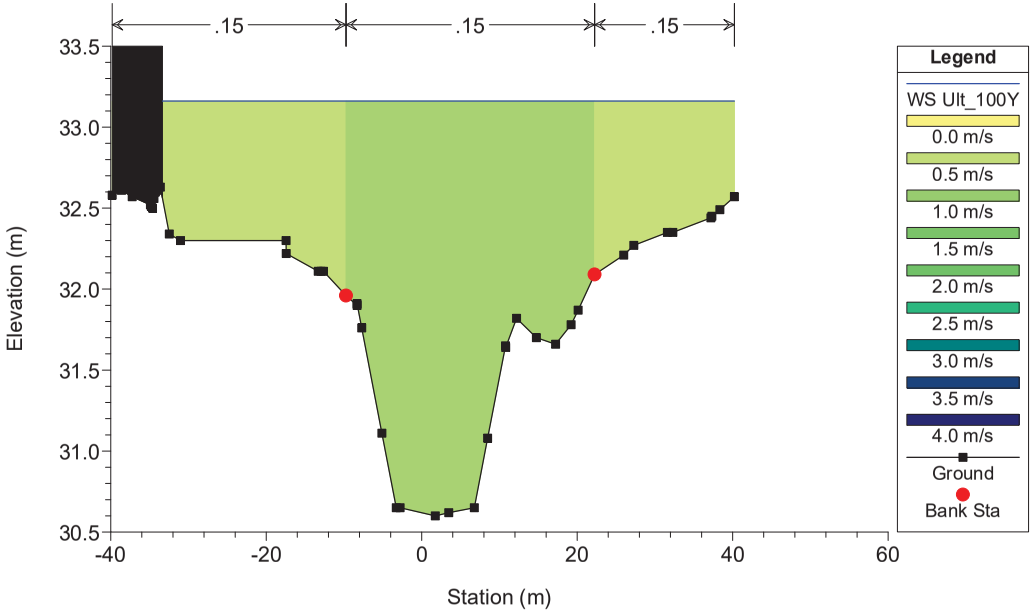
\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2254



\\bnenas01\projects\16\003350 - Jimboomba Celestino Subdivision\6_Model\HECRAS\ROL1\Rev02\ROL 1 Riverside 02 Plan: Plan 02 Chnl Mod02 20/06/2017 2:56:17 PM

Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2222



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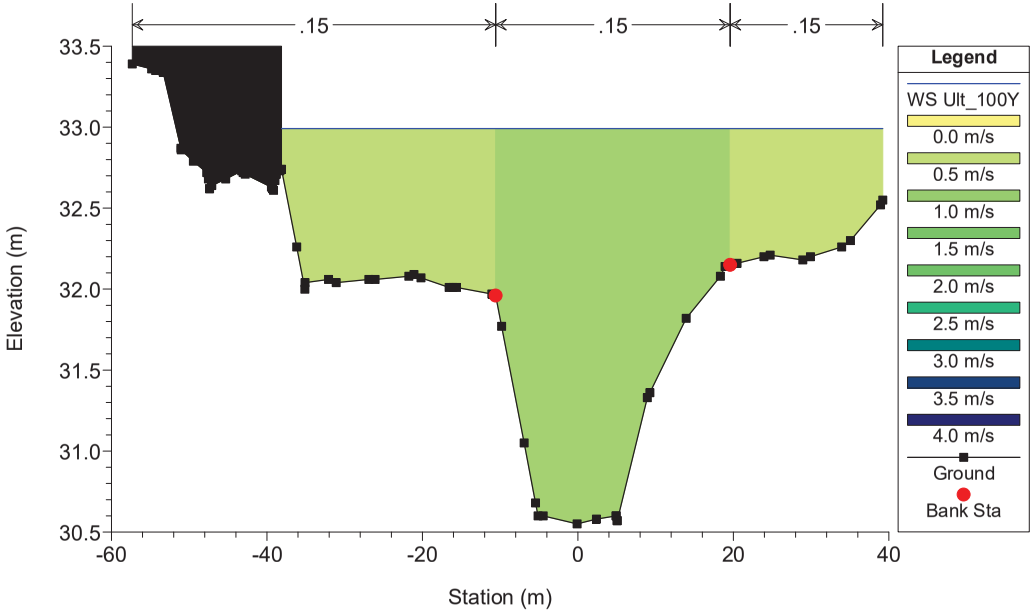
Geom: Geom 02 Chnl Mod 02 Flow: Flow 01
River = w channel 02 Reach = 526 RS = 2195



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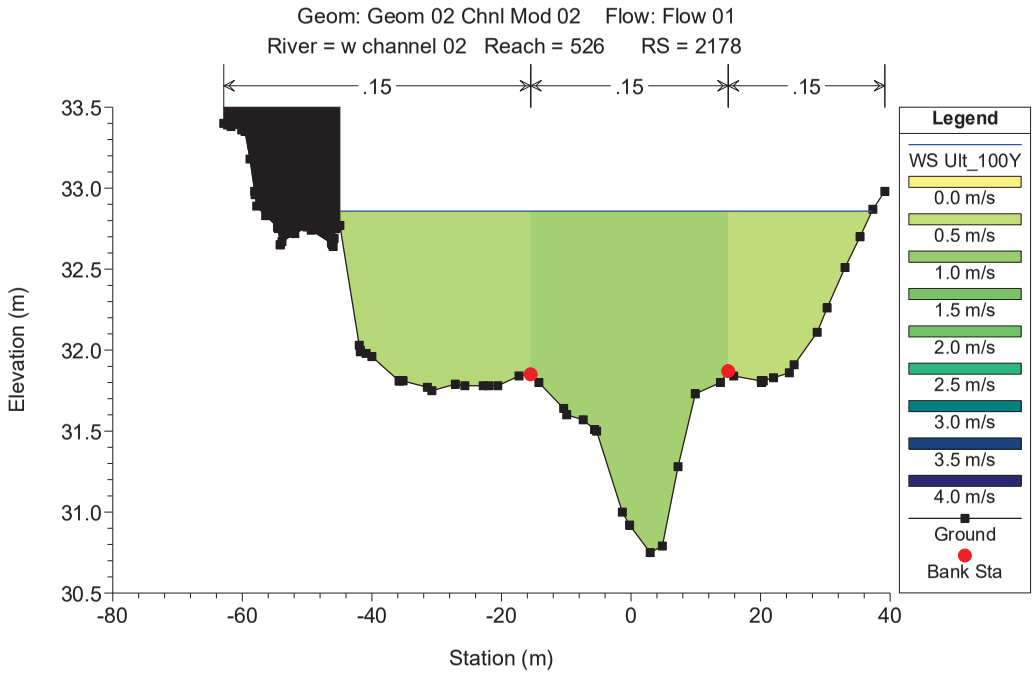

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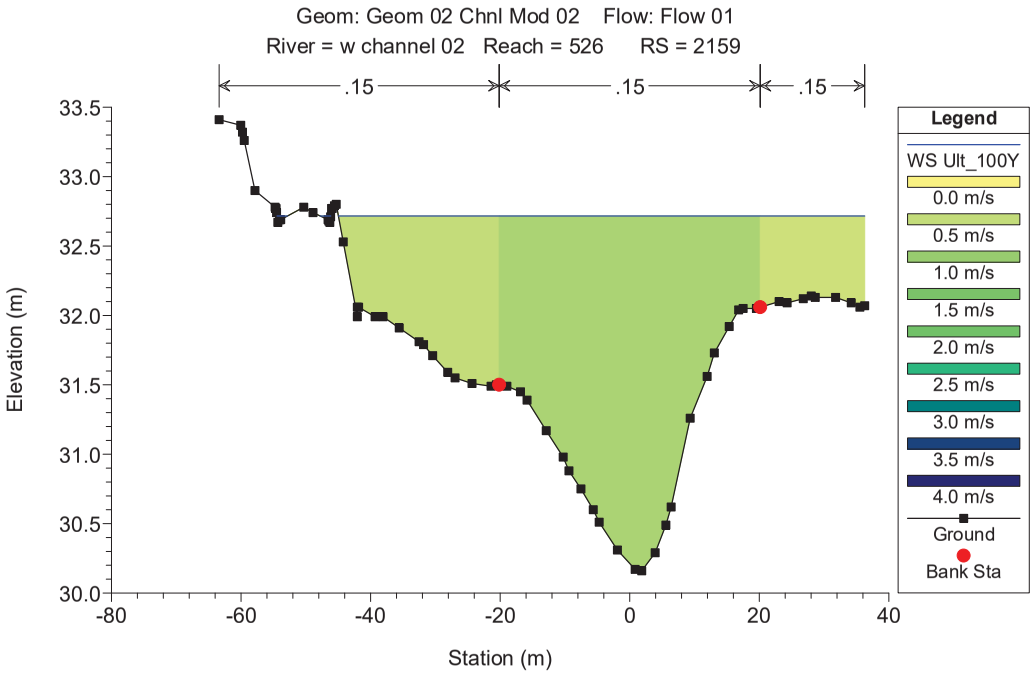

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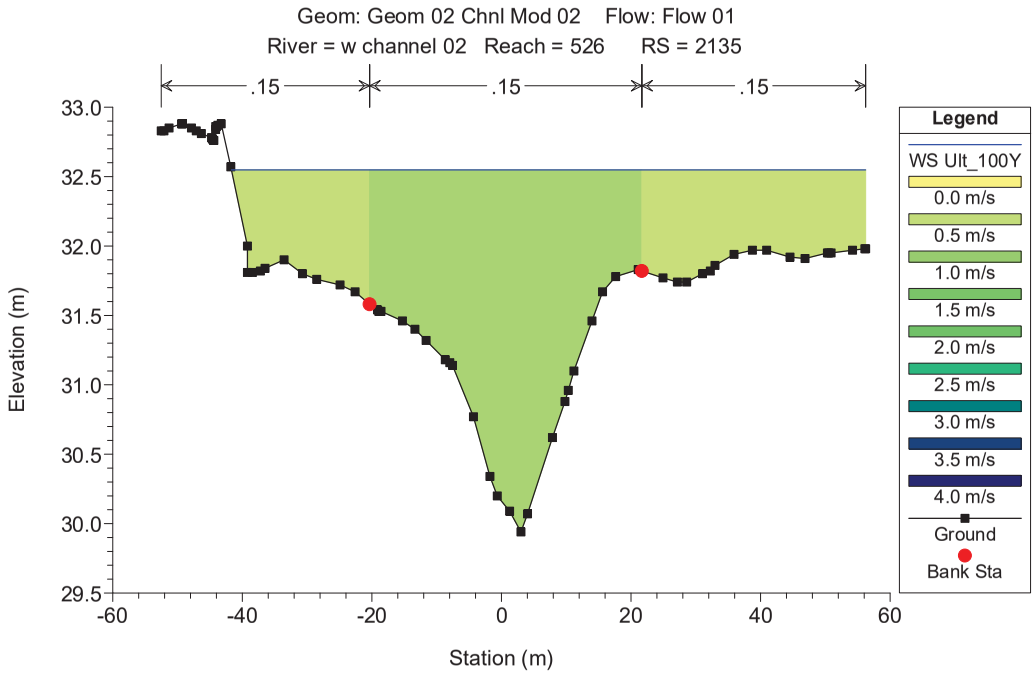

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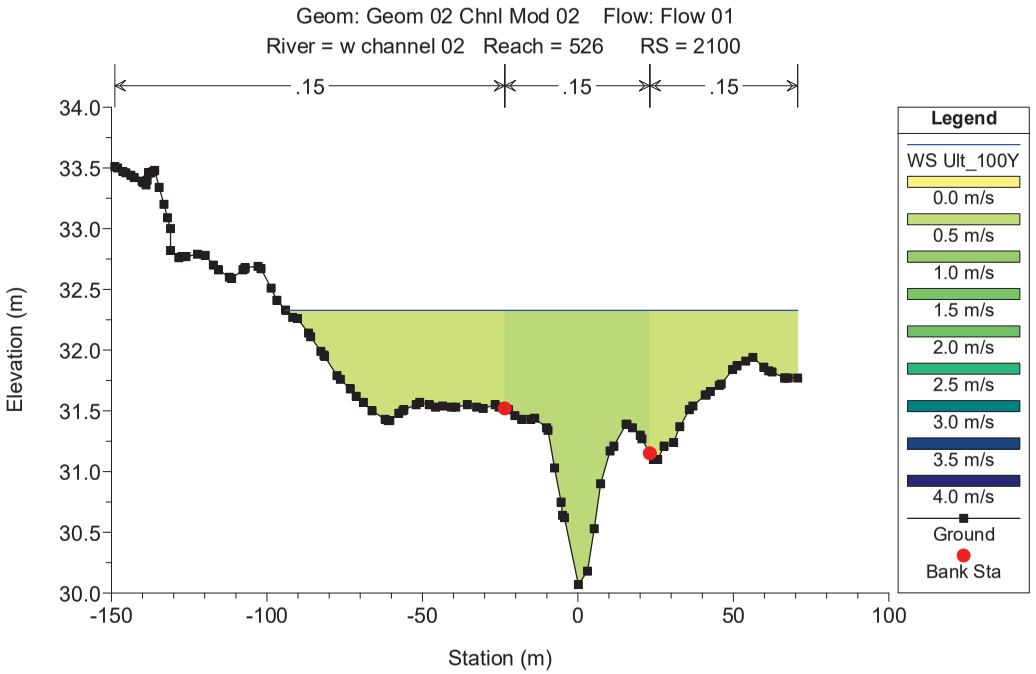

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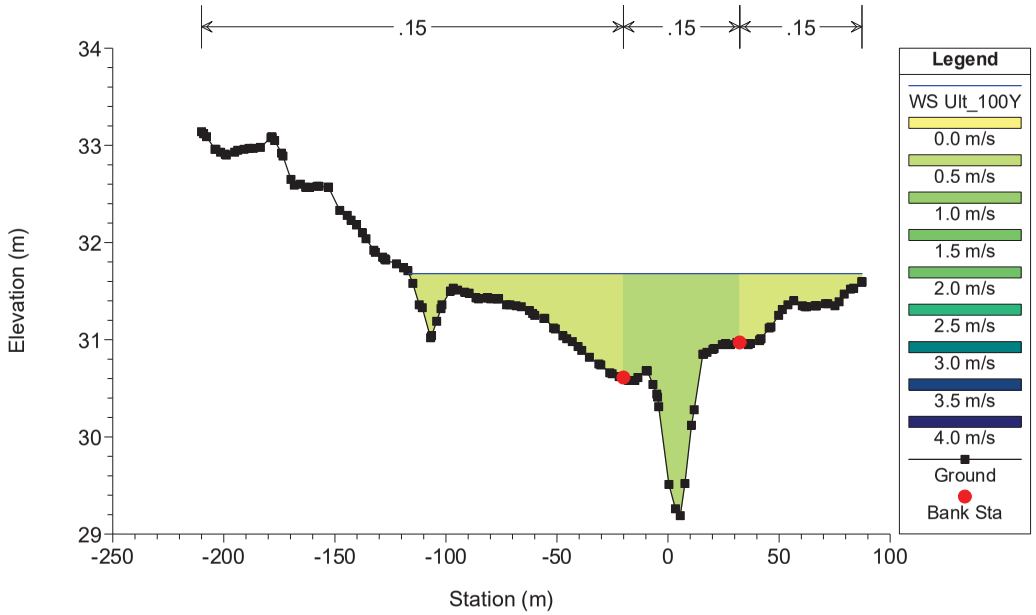
Geom: Geom 02 Chnl Mod 02 Flow: Flow 01

River = w channel 02 Reach = 526 RS = 1989



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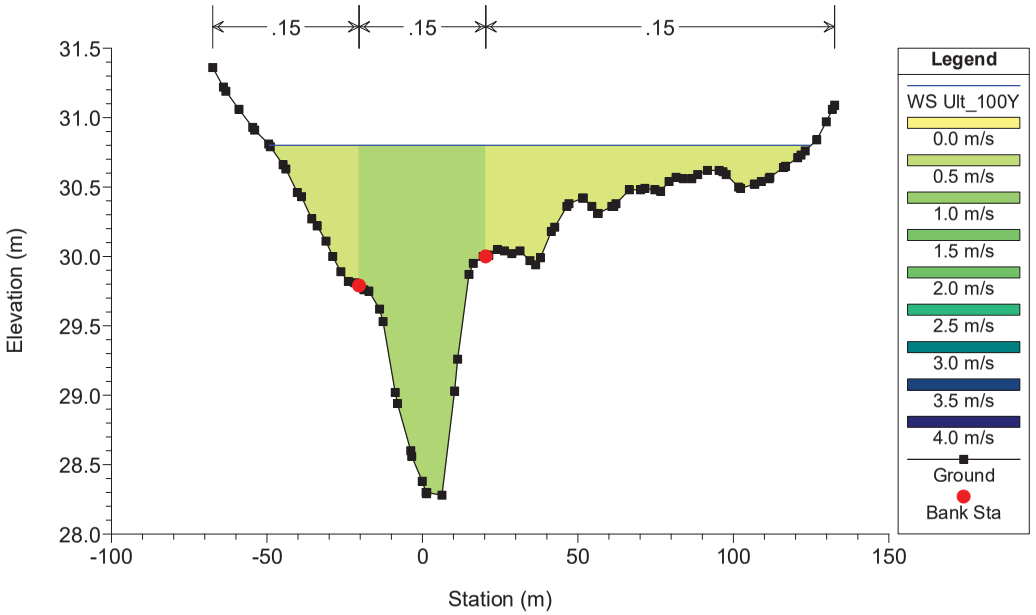
Geom: Geom 02 Chnl Mod 02 Flow: Flow 01

River = w channel 02 Reach = 526 RS = 1848



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Geom: Geom 02 Chnl Mod 02 Flow: Flow 01

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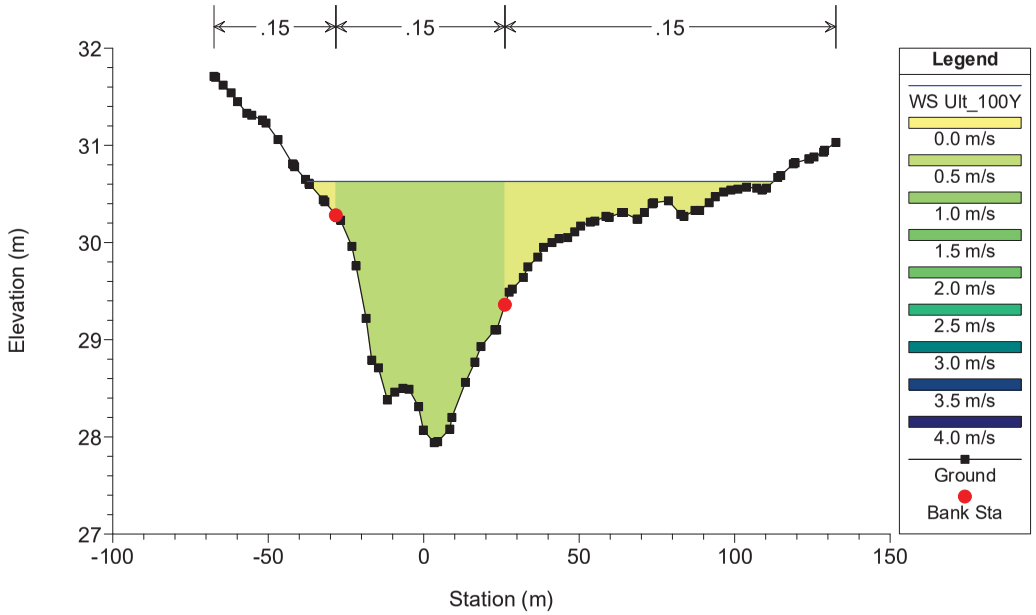

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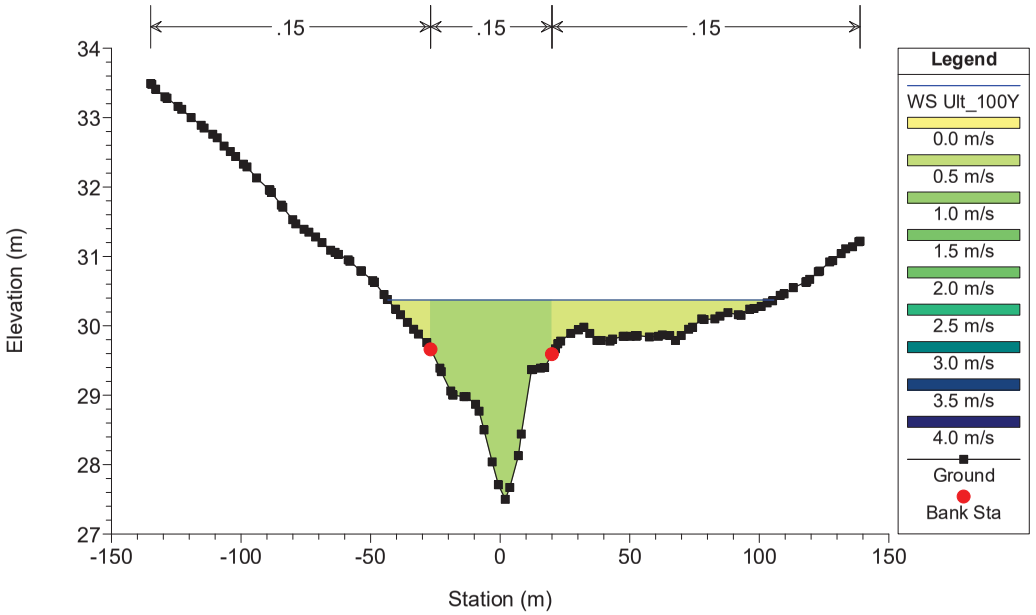

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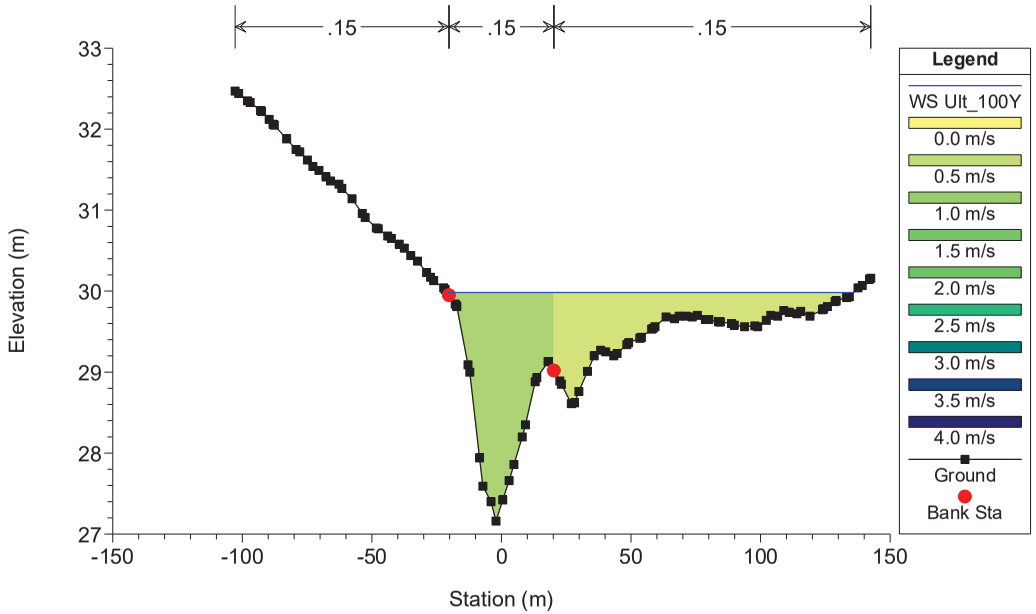

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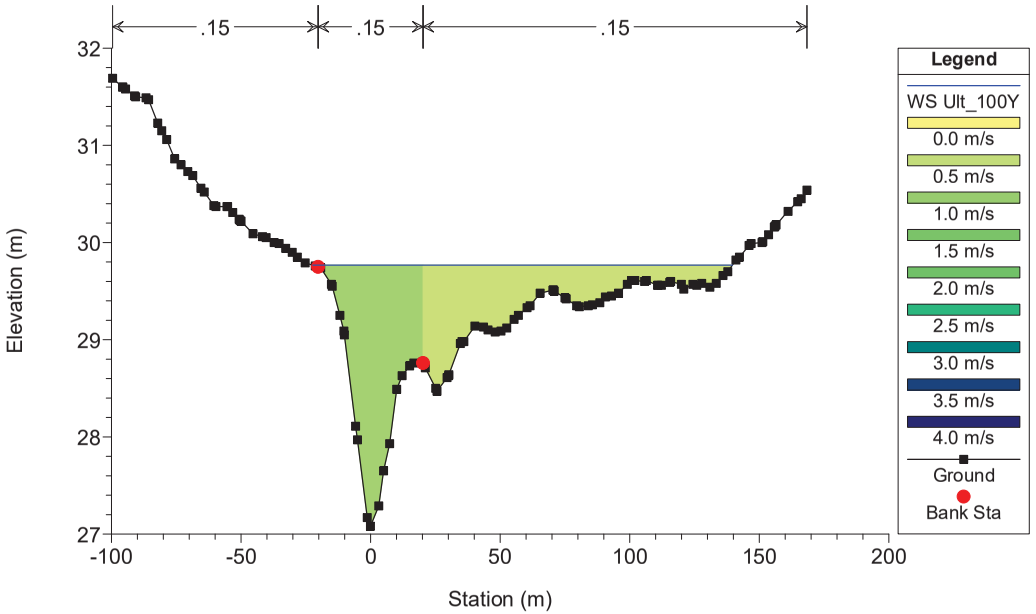

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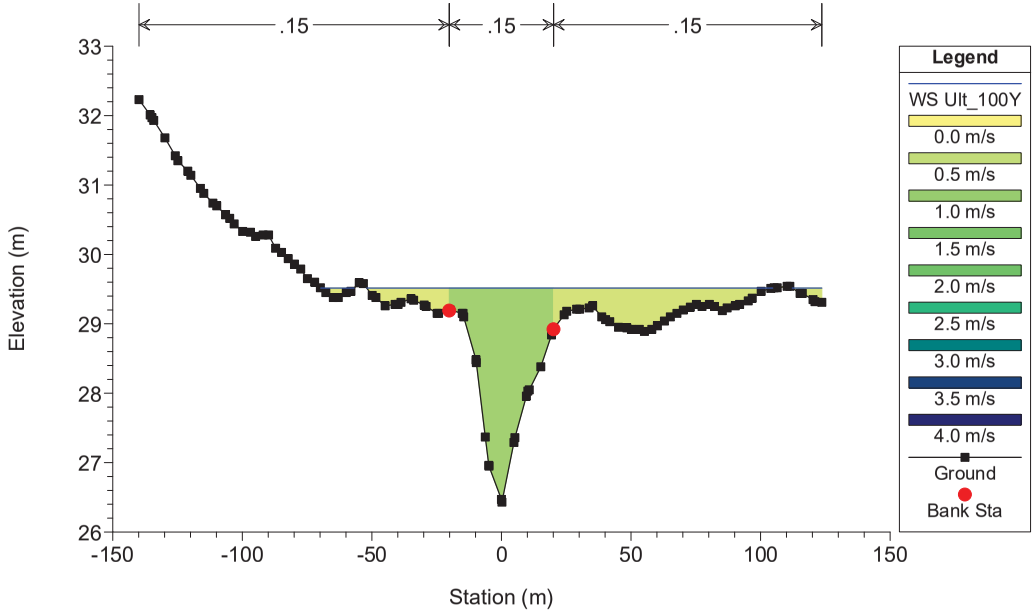

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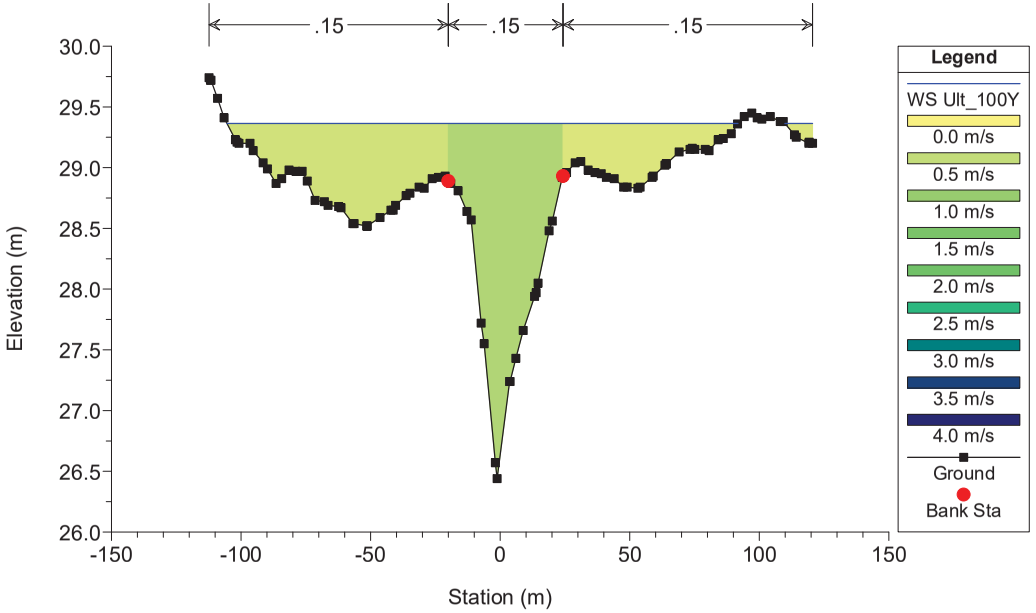

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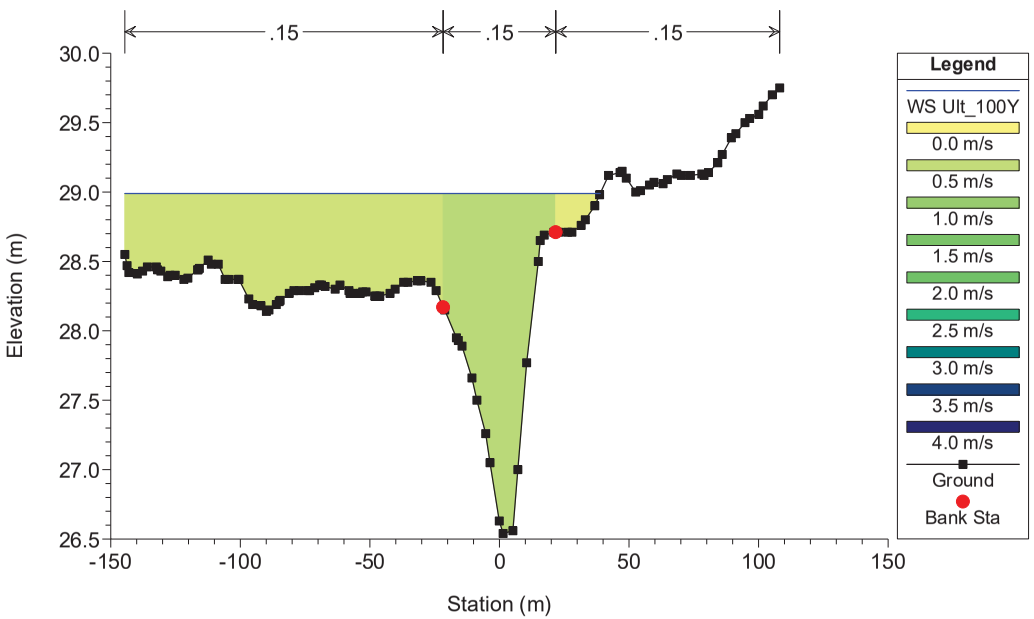

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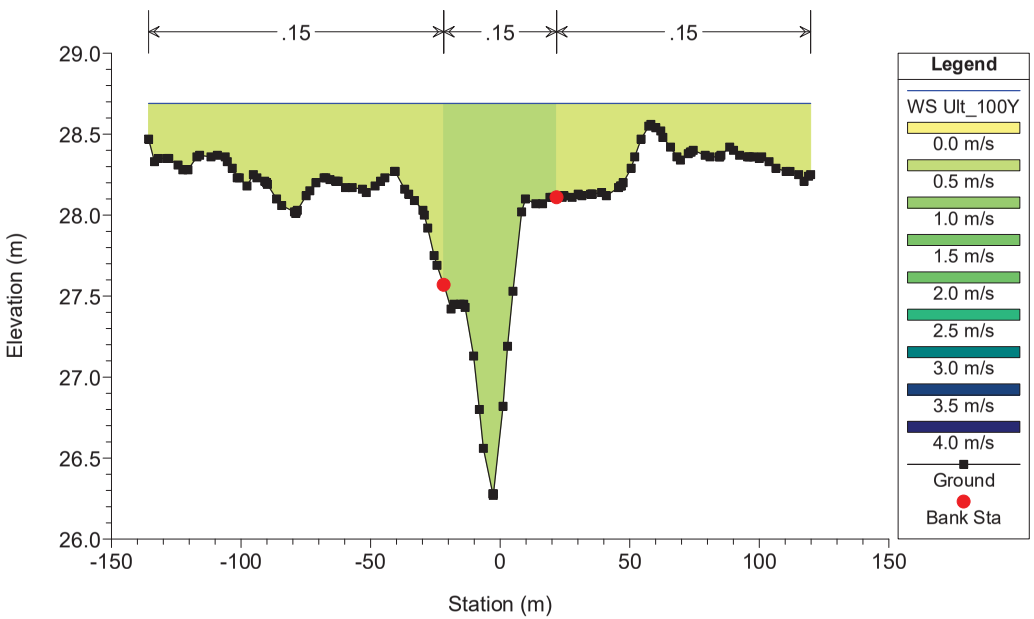

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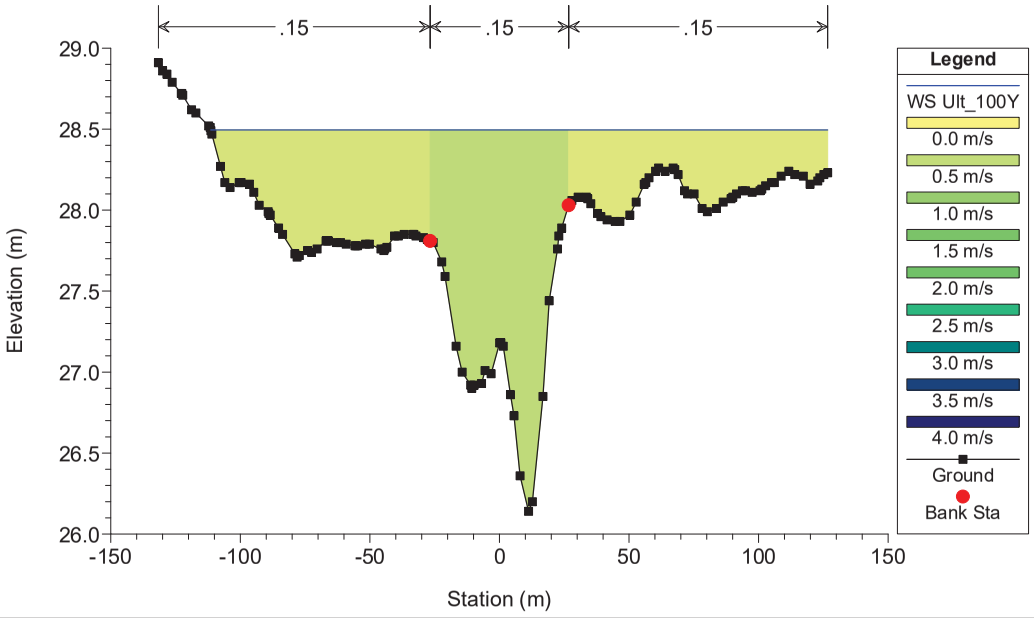

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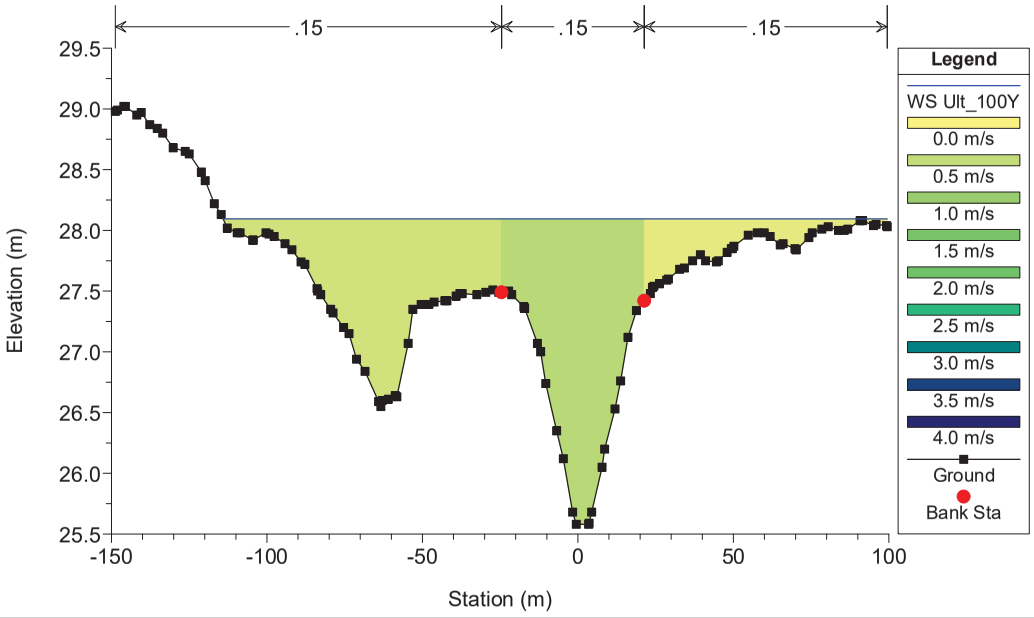

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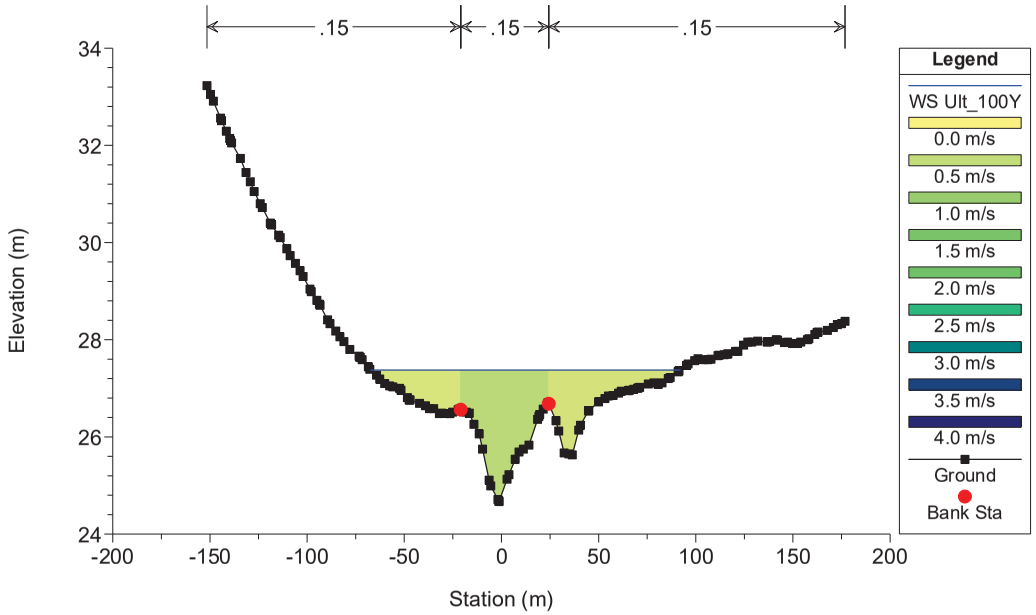

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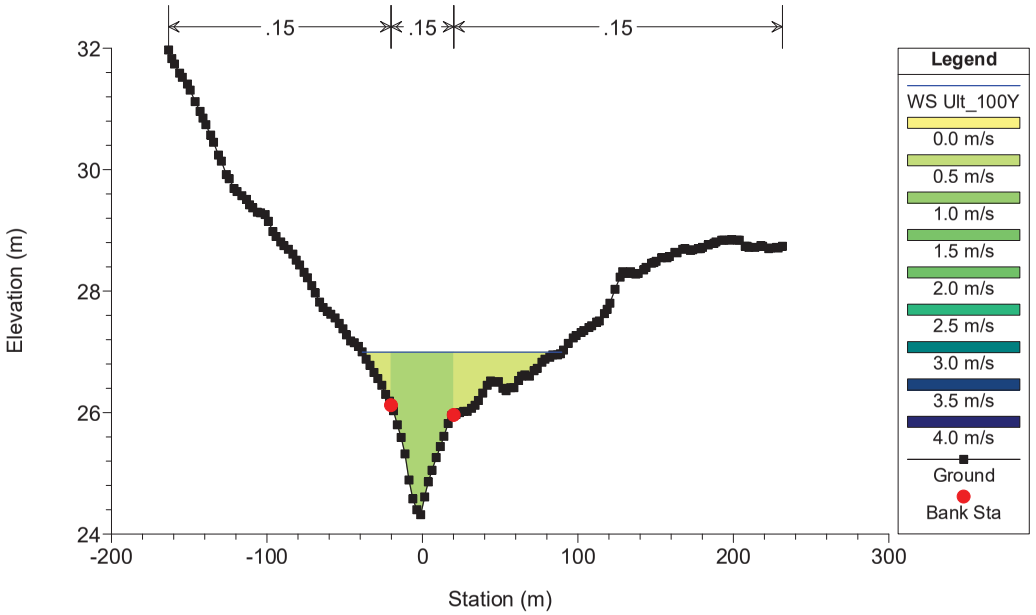

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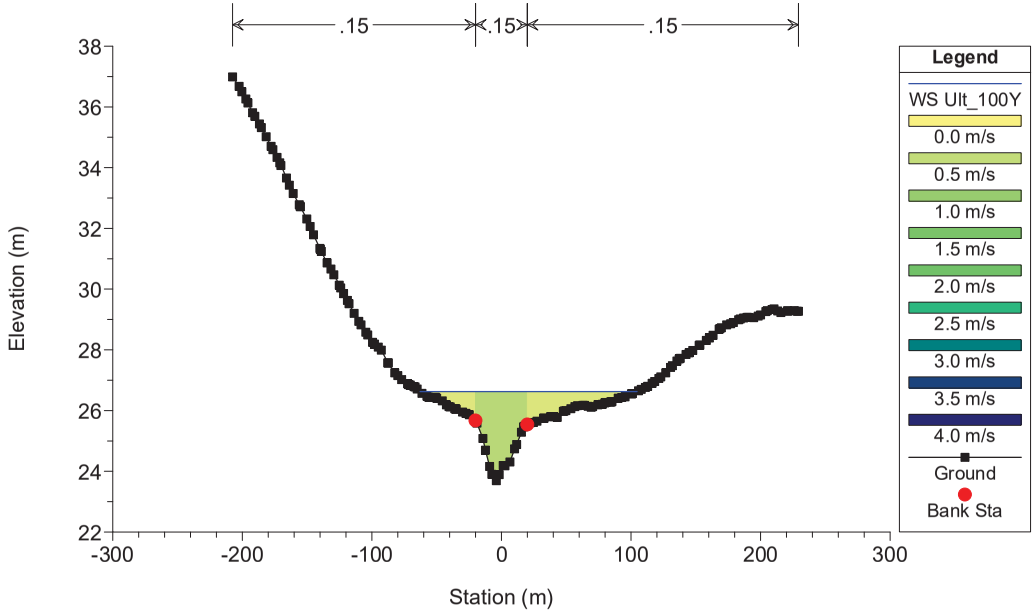

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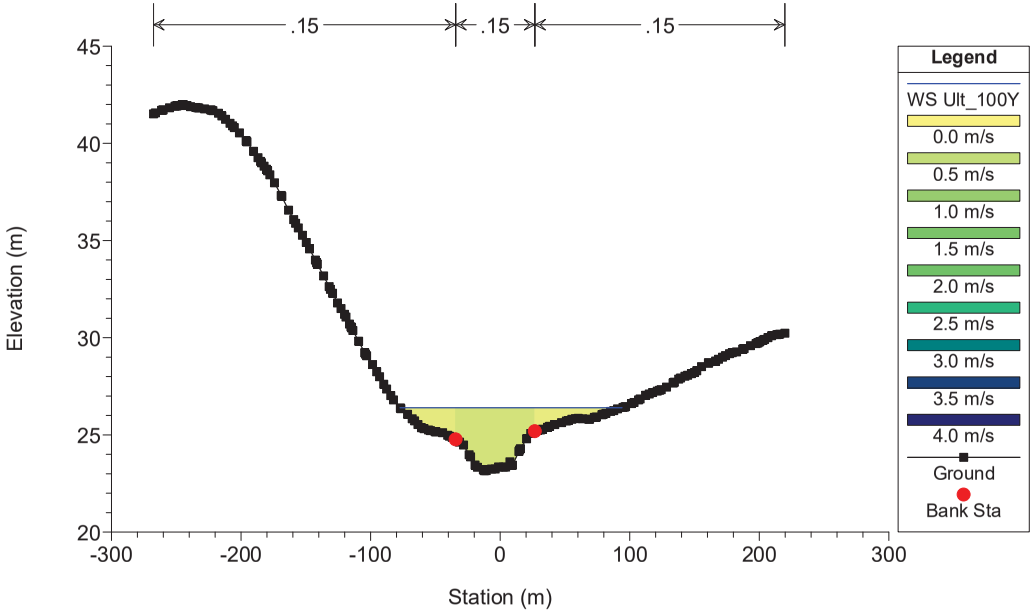

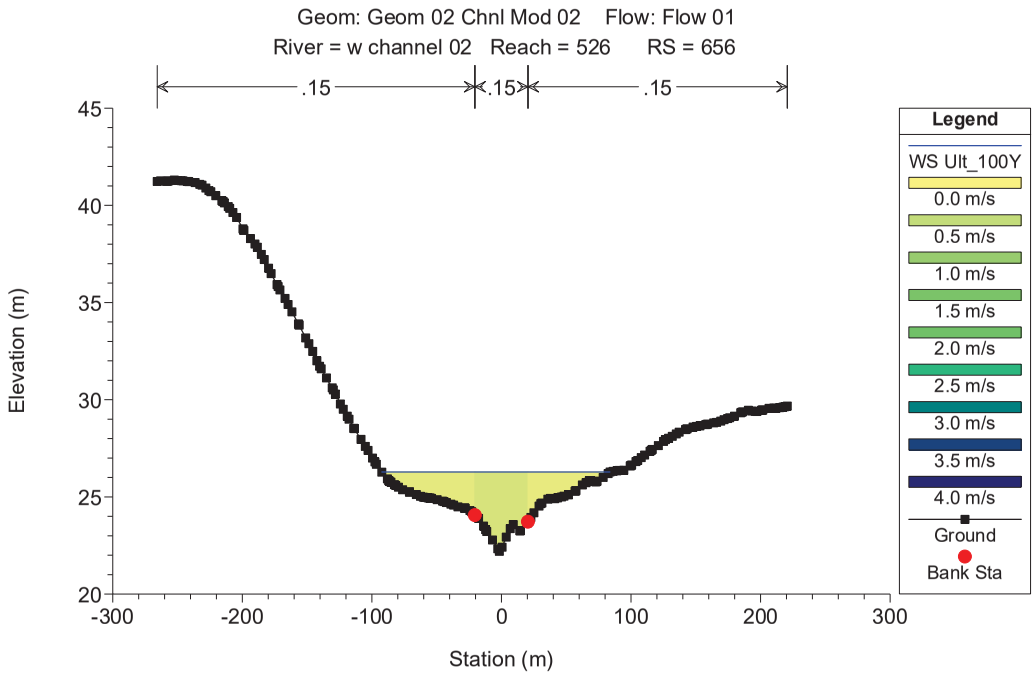

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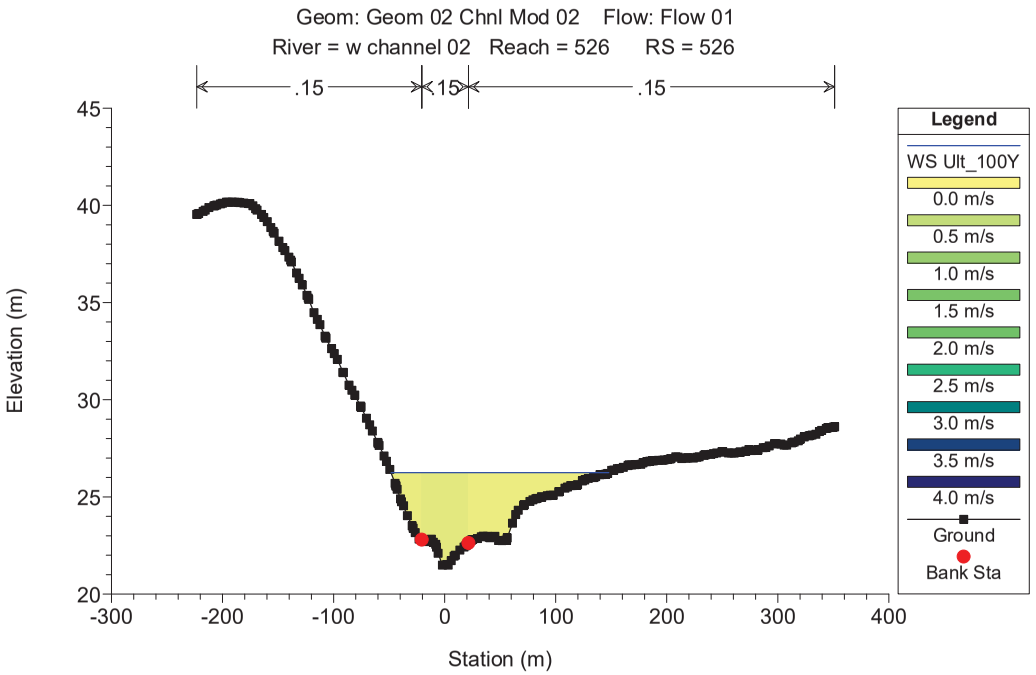


ROL1 – RIVERSIDE, JIMBOOMBA

Appendix E Living Waterways Table & Plans

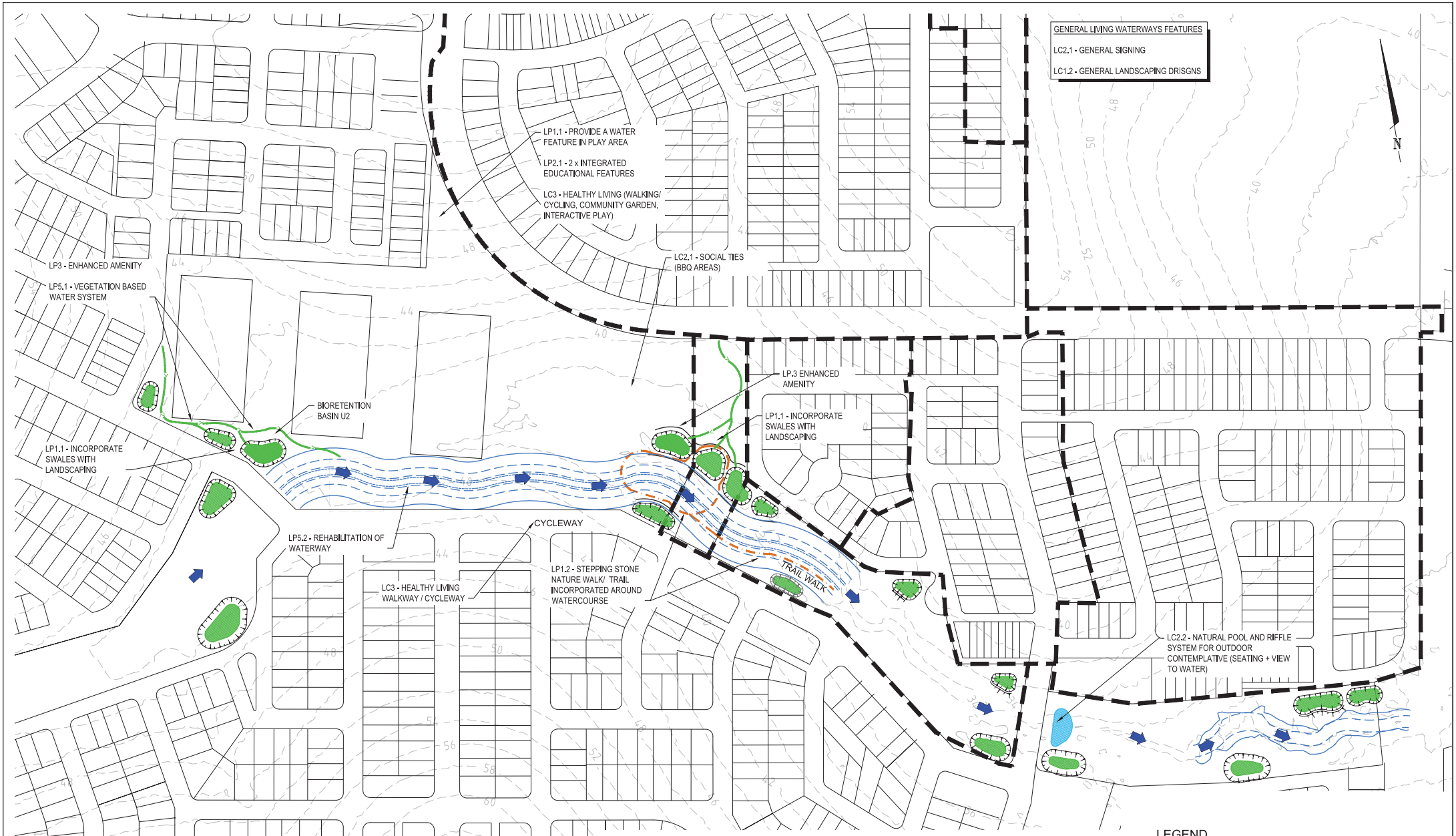
CELESTINO PTY LTD

Living Waterways Summary Table – Stormwater Quality Precinct A

Living Waterways	Reference		Desired Outcomes	Credit Available	Credit Achieved	Design Features / Implementation
(LW) LIVING WATERWAYS: Protect and enhance our water systems and their environments	**LW1**	LW 1.1	Pervious Surfaces 12 credits =< 20% impervious 8 credits =< 30% impervious 6 credits =< 40% impervious 4 credits =< 50% impervious	12	0	Fi for Precinct A is 55%-60%, which is higher than 50% impervious areas to achieve 2 credits.
		LW 1.2	Runoff Pollution is minimised 12 credits = pollutant loads are 25% below target loads 8 credits = SW loads meet target 2 credits = pollutant loads 50% above target	12	7	Slightly lower than SPP 2016 targets.
	LW2	LW 2	Development that does not diminish waterways or critical catchment and ecological processes	**N/A – Mandatory Requirement**	**Achieved**	Stormwater Management Report (**B13343.W-02B**) demonstrates compliance with State and local requirements to protect downstream waterways.
	LW3	LW 3	Protected riparian and aquatic habitats (Includes a minimum 25m vegetated buffer from top of high bank and rehabilitation of degraded waterway and riparian sections)	**N/A – Mandatory Requirement**	**Achieved**	>100m setback from Logan River embankments, however not applicable to SWQ Precinct A.
	LW4	LW 4	Onsite stormwater solutions that are locally appropriate	**N/A – Mandatory Requirement**	**Achieved**	Locally appropriate stormwater controls have been adopted such as bioretention devices and swales, as per Stormwater Management Report (**B13343.W-02B**).
	LW5	LW 5	Construction processes that prevent erosion and do not result in muddy waters leaving the site	**N/A – Mandatory Requirement**	**Achieved**	Appropriate and standard construction procedures and erosion sediment control is proposed and will be undertaken.
(LP) LIVING PLACES: Create Places that people can connect with because they are liveable, beautiful, educational, and inspiring	**LP1**	LP 1.1	Ranges of Experience i) a variety of sensory vegetation connected with stormwater management system ii) a water management system that utilises swales and/or natural drainage lines to draw attention to 'line' of SW trail iii) design outcome that accounts for the creation of a variety of sounds, rhythms and volumes iv) design outcome that allows users to touch the water system 1 credit = two design elements as per (i) to (iv)	2	2	Design Feature: (two required): i) Stepping stones to be incorporated in Bioretention Basin U1 ii) swales to be incorporated into district park area for conveyance of stormwater.
		LP 1.2	Outdoor wild experience i) visual and physical encounters with onsite water corridors or water locations. ii) clear points of entry into system - visually inviting and safely accessible iii) safe play and/or exploration associated with the water system 4 credits = design element as per i + ii + iii	4	4	Design Feature: i) Circular Nature Walk across the watercourse ii) Entry from cycleway and Bioretention Basin U1 iii) Safe design of nature walk
	LP2	LP 2.1	Integrated Education Design to provide a minimum of two educational or interpretive elements that draw attention to and explain water values. 2 credits = 2 education elements	2	2	Design Feature: 1. Two educational elements – refer to Landscape drawings for details. 2. As above.
		LP 2.2	Interactive and Education Elements: The planning of landscaping and stormwater management systems provide for a design outcome which incorporates educational or interpretive elements that are interactive (a minimum of two separate elements). 4 credits = 2 education elements	4	4	Design Feature: 1. Two interactive elements – refer to Landscape drawings for details. 2. As above.
	LP3	LP 3	Enhanced Amenity i) Unified landscape and SW design ii) at least 1 SW treatment system designed to high aesthetic standards and integrated with site design and located in a prominent location 4 credits = i + ii	4	4	Design Feature: i) Integrated Landscaping in Bioretention Basins ii) high aesthetic standard of Bioretention Entrance Basin And Bioretention Basin U1.
	LP4	LP 4	Natural, Historical and Cultural Identity i) utilise local cultural and heritage significance - unique character of the community ii) design recognises and reflects cultural or heritage significance as part of the unique character of a community or locality 4 credits = i + ii	4	0	Cultural or historical links not expected for the site.

Living Waterways Summary Table – Stormwater Quality Precinct A

Living Waterways	Reference		Desired Outcomes	Credit Available	Credit Achieved	Design Features / Implementation
	LP5	LP 5.1	Biodiversity Values: i) vegetation based water systems and other site landscape reflect local ecosystem ii) public spaces retain and incorporate indigenous plant communities into the landscape design 1 credit per i and/or ii - max 2 credits	2	2	Design Feature: i) landscaping reflects local ecosystem ii) indigenous planting
		LP 5.2	Biodiversity Rehabilitation: Development maximises the opportunities for rehabilitation of waterways and riparian corridors. Revegetated waterway/riparian corridor.	2	2	Design Feature: Rehabilitation of watercourse. Refer to Landscaping drawings for further details.
(LC) LIVING COMMUNITIES: Create versatile places that enable safe, healthy, inclusive and resilient communities	**LC1**	LC 1.1	Water Harvesting: 12 credits => 80% of non-potable demands 8 credits => 60% of non-potable demands 4 credits => 40% of non-potable demands 2 credits => 20% of non-potable demands	12	0	Design Feature: - RWTs will be provided for commercial areas
		LC 1.2	Landscape: (material and management) i) landscape materials - retain existing landscape features and veg onsite/optimise shade/minimise turf ii) landscape management - minimise the need for irrigation, fertilisation, weeding and maintenance	2	2	Design Feature: i) General landscaping design – refer to Landscape drawings. ii) General landscaping design – refer to Landscape drawings.
	LC2	LC 2.1	Social ties: 1 credit per below i) shared outdoor group seating ii) shared eating and cooking facilities - covered BBQ area iii) signage to highlight public use iv) inclusion of a social space - productive garden/playground	4	4	Design Feature: i) Seating incorporated in sports park area ii) BBQ Areas iii) Signage incorporated iv) Social spaces – playground, bbq area, etc.
		LC 2.2	Outdoor contemplative values i) outdoor seating for quiet contemplation ii) seating with view to water	2	2	Design Feature: i) Seating incorporated in sports park area for quiet contemplation ii) Natural pool and riffle systems upstream / downstream of the future culverts with viewing platform and outdoor seating
	LC3	LC 3	Healthy Living i) Developed sense of ownership through passive recreational activities ii) Site incorporates and/or connects with walking/ cycling tracks. iii) Play spaces that encourage natural or interactive play opportunities. iv) There is a direct link with recreation, landscape and water features on the site	4	4	Design Feature: i) nature walk, higher density sites (could have community gardens), could have edible forest ii) walking/ cycling tracks. iii) sports field iv) nature trail, biobasin, etc.
	LC4	LC 4	Sustainable and resilient communities	**N/A – Mandatory Requirement**	**Achieved**	Site layout has considered natural hazard implications and the protection of property and public safety. All lots are above flood hazards in Site Tributary and Logan River and appropriate bushfire buffers are provided.
	LC5	LC 5	Safe and welcoming places	**N/A – Mandatory Requirement**	**Achieved**	Engineering and landscaping design shall be undertaken for the protection of property, public safety and health.
(LLE) LIVING LOCAL ECONOMIES: Provide affordable, enduring solutions that are viable to build, use and maintain	**LLE1**	LLE1	Water systems that consider whole of life costs	**N/A – Mandatory Requirement**	**Achieved**	Whole of lifecycle costs have been considered for the stormwater quality measures implemented to minimise ongoing maintenance and renewal costs.
	LLE2	LLE1	Water systems that consider maintenance and access requirements	**N/A – Mandatory Requirement**	**Achieved**	Access to treatment systems will be per Best Practice Management to be outlined in the Stormwater Management Plan.
			TOTAL POINTS AVAILABLES **- 1 Drop: 36 to 40 credits** **- 2 Drops: 41 to 54** **- 3 Drops: 55 credits and above**	**72**	**39**	



CONCEPT PLAN ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE LATEST VERSION OF CALIBRE CONSULTING REPORT No. 16-003350.R02-SWMP
2. REFER TO LANDSCAPING DRAWINGS FOR FURTHER DETAILS OF LIVING WATERWAYS FEATURES.

LEGEND

- MUSIC CATCHMENT BOUNDARIES
- EXISTING LIDAR CONTOURS
- PROPOSED LOT BOUNDARIES
- FLOW ARROW

REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	21.06.17	ORIGINAL ISSUE	RH	CM
B	05.12.17	ROL1 UPDATE	RH	GB
C				
D				
E				
F				
G				
H				

DRAWN
DESIGN

STATUS: NOT FOR CONSTRUCTION
APPROVED

SCALE
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1:3000 A3

CLIENT: Riverside CELESTINO

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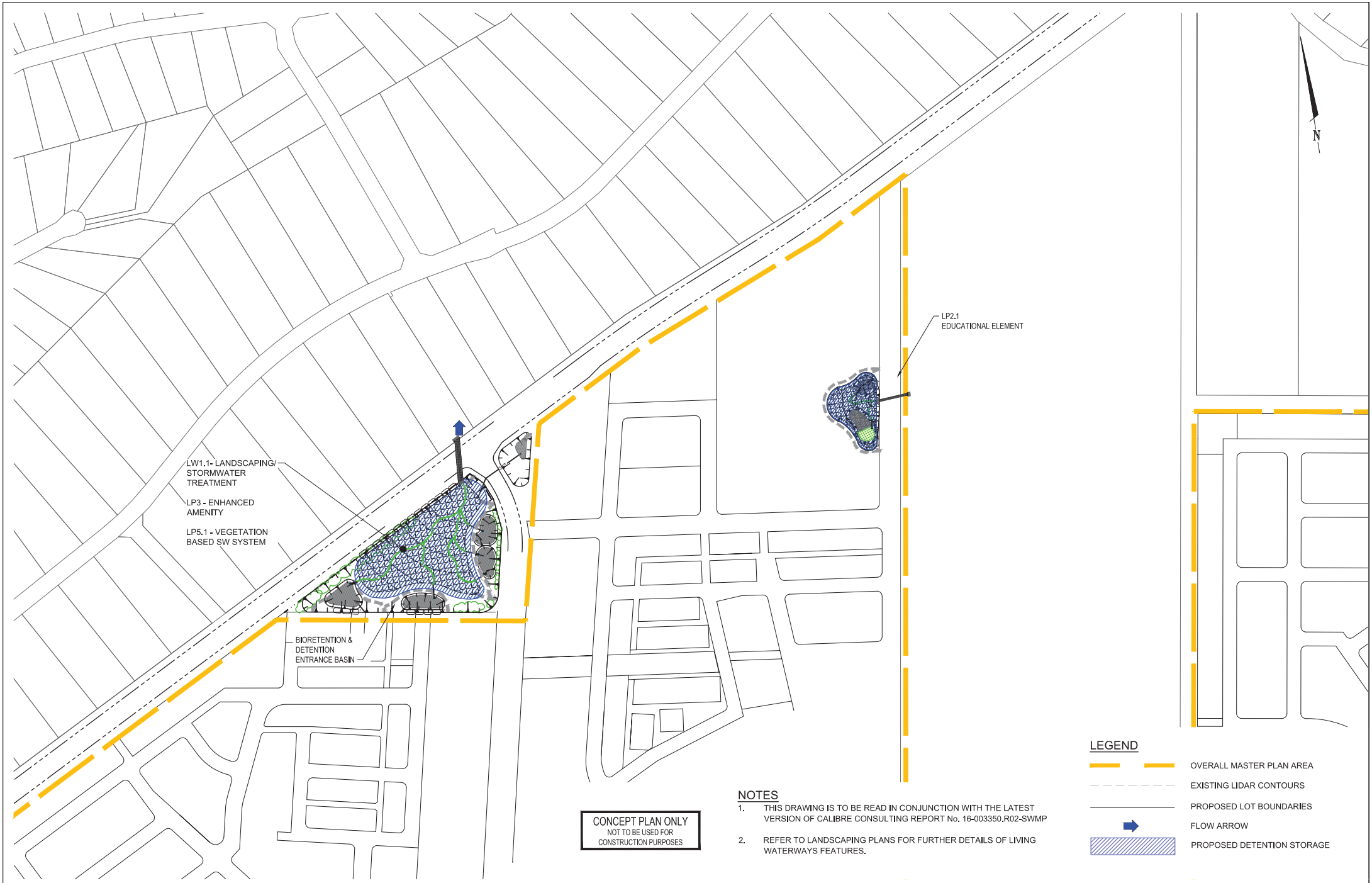
PROJECT: RIVERSIDE CELESTINO JIMBOOMBA

DISCLAIMER
ALL DIMENSIONS TO BE CHECKED ON SITE BY CONTRACTOR PRIOR TO CONSTRUCTION. USE WRITTEN DIMENSIONS ONLY, DO NOT SCALE.

DRAWING TITLE: PRECINCT A - CONCEPT LIVING WATERWAYS FEATURES PLAN (1 OF 2)

PROJECT No.	DRAWING No.	REVISION
16-003350	SK104	B



CONCEPT PLAN ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE LATEST VERSION OF CALIBRE CONSULTING REPORT No. 16-003350.R02-SWMP
2. REFER TO LANDSCAPING PLANS FOR FURTHER DETAILS OF LIVING WATERWAYS FEATURES.

LEGEND

- OVERALL MASTER PLAN AREA
- EXISTING LIDAR CONTOURS
- PROPOSED LOT BOUNDARIES
- FLOW ARROW
- PROPOSED DETENTION STORAGE

REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	20.06.17	FOR ROL STAGE 1 SUBMISSION	CM	RH
B	08.12.17	ROL1 UPDATE	RH	GB
C				
D				
E				
F				
G				
H				

DRAWN
DESIGN

STATUS: **NOT FOR CONSTRUCTION**
APPROVED

SCALE
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1:4000 A3

CLIENT: Riverside CELESTINO

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PROJECT: **RIVERSIDE CELESTINO JIMBOOMBA**

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DRAWING TITLE: **PRECINCT A - CONCEPT LIVING WATERWAYS FEATURES PLAN (2 OF 2)**

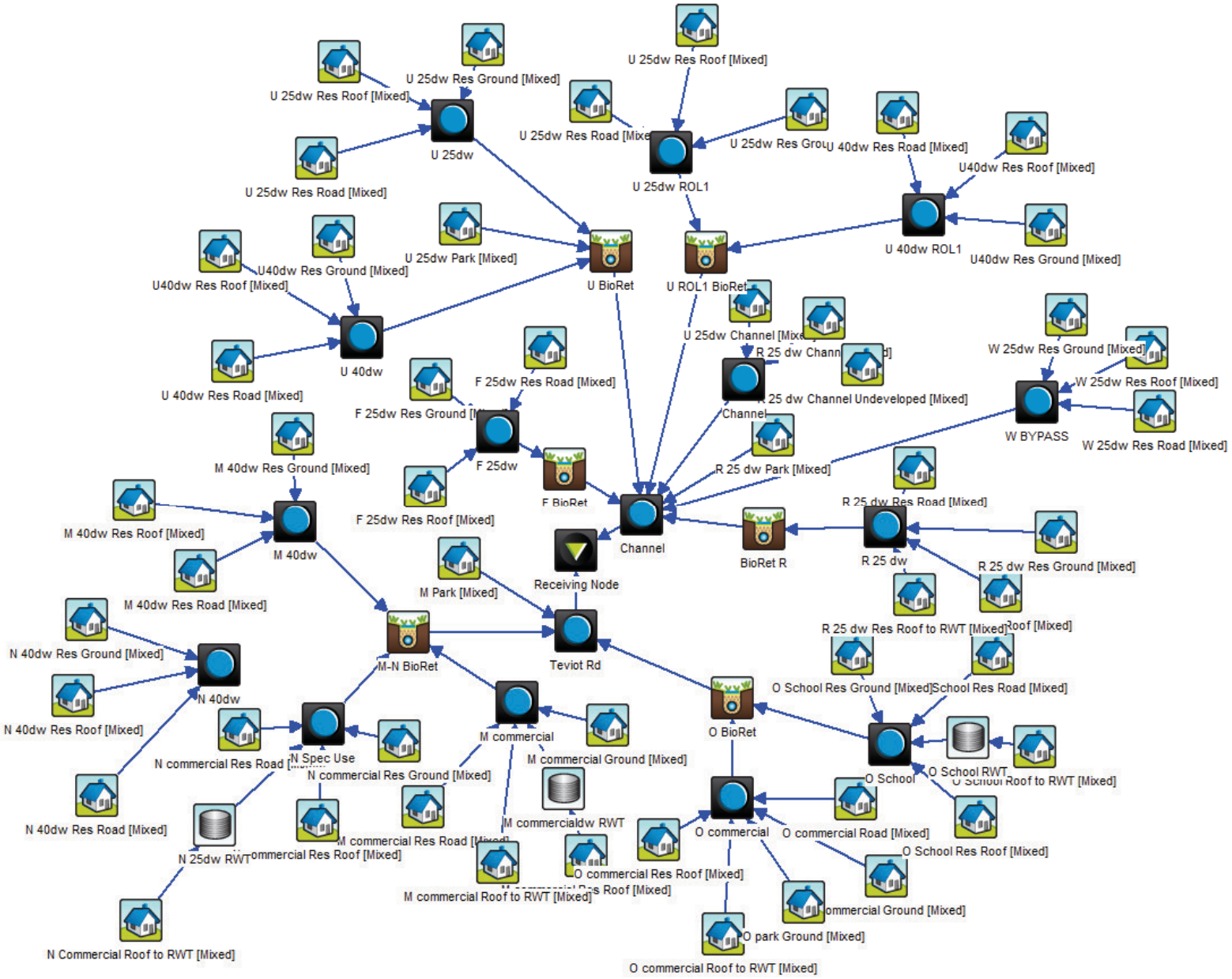
PROJECT No.	DRAWING No.	REVISION
16-003350	SK105	B

ROL1 – RIVERSIDE, JIMBOOMBA

Appendix F MUSIC Modelling Details

CELESTINO PTY LTD

MUSIC Modelling Layout



ROL1 – RIVERSIDE, JIMBOOMBA

Appendix G Maintenance Details

CELESTINO PTY LTD

Bioretention Basin Inspection & Maintenance Requirements

Treatment Device / Property	Inspection	Inspection Frequency	Maintenance
Bioretention Basin			
Litter & Weeds	Visually check for litter, weeds and debris within the Bioretention Basin.	Quarterly for first year then every six months after establishment. Also after significant storm events.*	Remove litter, weeds and debris from the basin and dispose of at approved waste disposal facility.
Inlet and Outlet	Visually check for blockages within the upstream and downstream inlet pits. Check for locked weep holes within the upstream pit.		Remove any blockages or debris within inlet pits or blockages to weep holes.
Sedimentation	Visually check surface of Bioretention Basin for accumulation of sediment.		If sediment build-up is observed, remove accumulated sediment where it is smothering vegetation.
Scour, Erosion and Vehicle Damage	Visually check Bioretention Basin surface for scouring and areas of erosion or vehicle damage.		Repair damage to Bioretention Basin surface and filter media if exposed. Undertake replanting if necessary and maintain watering of area until vegetation has established.
Vegetation	Visually check for any planted vegetation that has died.	Quarterly for first year then every six months after establishment.	Remove dead vegetation and replace with stock of equivalent size and species as detailed in plant schedule. Maintain watering until new vegetation has established.
Filter Media	Check surface of Bioretention Basin for any isolated “boggy” areas.	Every six months.	Increase infiltration rate by tilling the surface of the filter media.
	Visually check and determine time of ponding within basin after a storm event.*	During wetter periods.	If duration of ponding exceeds 48 hours, trial tilling of the surface of the filter media. If no improvement occurs then dispose and replace the top 100 to 150mm layer of filter media (below is the detailed procedure): i. Remove vegetation and store for replanting. ii. Remove top 150mm of filter media and dispose of in an approved manner. iii. Till the remaining filter media to a further depth of 300mm. iv. Place a new layer of appropriate filter media; v. Replant removed vegetation
Subsoil Drainage	Check subsoil drainage for blockages. This is subject to earlier stages of inspection. To discover blockage, flush subsoil drain from the upstream inspection opening. If there is no evidence of a blockage, no further action is required.	Subject to earlier stage of inspection.	If blockage is discovered remove by flushing out the subsoil drainage pipe. Below is an outline of the procedure i. Set up a pump and an appropriate collection device (i.e. a sandbag) at the downstream pipe. ii. Draw outflow through pipe, not allowing any sediment/silt to enter the downstream stormwater drainage system. iii. Collect and dispose flushed material appropriately.

* Significant Rain Event defined as a 24 hour period with rainfall greater than 200mm, or shorter period with an average rainfall intensity greater than 20mm/hour.

BIORETENTION BASIN INSPECTION & MAINTENANCE CHECKLIST

SQID:	
Location:	
Date:	
Time:	
Inspector:	
Weather Conditions	

	Condition Acceptable			
Maintenance Item	**Yes**	**No**	**N/A**	**Comments**
1. Basin Surface				
Clear of sediment build-up				
Check for erosion, scour, vehicle & other damage				
Check for dead or damaged vegetation				
2. Filter Media				
Check for erosion, scour, vehicle & other damage				
Check for isolated boggy patches				
3. Subsoil Drainage				
Visually check subsoil drainage through cleanout inspection openings for build-up of sediment				
Check for blockages to subsoil drainage using other methods (eg. CCTV or flush-out)				

Additional Comments
Actions to be taken

GUIDELINES FOR FILTER MEDIA IN BIOFILTRATION SYSTEMS (Version 3.01) June 2009

The following guidelines for filter media in biofiltration systems have been prepared on behalf of the Facility for Advancing Water Biofiltration (FAWB) to assist in the development of biofiltration systems, including the planning, design, construction and operation of those systems.

NOTE: This is a revision of the previous FAWB guideline specifications (published in 2006 (Version 1.01), 2008 (Version 2.01)). It attempts to provide a simpler and more robust guideline for both soil-based and engineered filter media. FAWB acknowledges the contribution of EDAW Inc., Melbourne Water Corporation, Dr Nicholas Somes (Ecodynamics), Alan Hoban (South East Queensland Healthy Waterways Partnership), Shaun Leinster (DesignFlow) and STORM Consulting to the preparation of the revised guidelines.

Disclaimer

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1 GENERAL DESCRIPTION

The biofiltration filter media guidelines require three layers of media: the filter media itself (400-600 mm deep or as specified in the engineering design), a transition layer (100 mm deep), and a drainage layer (50 mm minimum cover over underdrainage pipe). The biofiltration system will operate so that water will infiltrate into the filter media and move vertically down through the profile.

The filter media is required to support a range of vegetation types (from groundcovers to trees) that are adapted to freely draining soils with occasional wetting. The material should be based on **natural or amended natural soils** or it can be **entirely engineered**; in either case, it can be of siliceous or calcareous origin. In general, the media should have an appropriately high permeability under compaction and should be free of rubbish, deleterious material, toxicants, declared plants and local weeds (as listed in local guidelines/Acts), and should not be hydrophobic. The filter media should contain some organic matter for increased water holding capacity but be low in nutrient content. In the case of natural or amended natural soils, the media should be a **loamy sand**.

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Maintaining an adequate infiltration capacity is crucial in ensuring the long-term treatment efficiency of the system. The ability of a biofiltration system to detain and infiltrate incoming stormwater is a function of the filter surface area, extended detention (ponding) depth, and the hydraulic conductivity of the filter media (Figure 1). Most importantly, design of a biofiltration system should optimize the combination of these three design elements.

For a biofiltration system in a temperate climate with an extended detention depth of 100 – 300 mm and whose surface area is approximately 2% of the connected impervious area of the contributing catchment, the prescribed hydraulic conductivity will generally be between 100 – 300 mm/hr in order to meet best practice targets (Figure 2). This configuration supports plant growth without requiring too much land space. In warm, humid (sub- and dry- tropical) regions the hydraulic conductivity may need to be higher in order to achieve the required treatment performance using the same land space (i.e., ensuring that the proportion of water treated through the media meets requirements).

Where one of these design elements falls outside the recommended range, the infiltration capacity can still be maintained by offsetting another of the design elements. For example, a filter media with a lower hydraulic conductivity may be used, but the surface area or the extended detention depth would need to be increased in order to maintain the treatment capacity. Similarly, if the available land were the limiting design element, the system could still treat the same size storm if a filter media with a higher hydraulic conductivity were installed. Where a hydraulic conductivity greater than 300 mm/hr is prescribed, potential issues such as higher watering requirements during the establishment should be considered. Biofiltration systems with a hydraulic conductivity greater than 600 mm/hr are unlikely to support plant growth due to poor water retention, and may also result in leaching of pollutants. However plant survival might be possible if the outlet pipe were raised to create a permanently submerged zone.

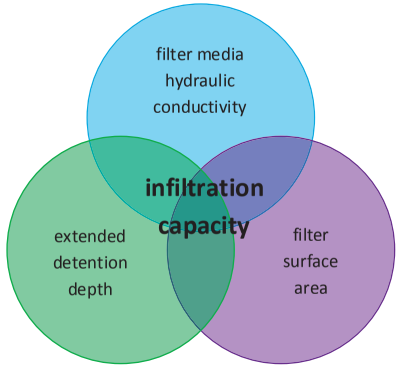

Figure 1. Design elements that influence infiltration capacity.

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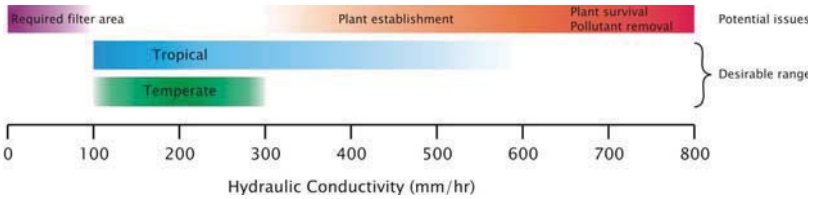

Figure 2. Recommended filter media hydraulic conductivity range and potential issues

The infiltration capacity of the biofiltration system will initially decline during the establishment phase as the filter media settles and compacts, but this will level out and then start to increase as the plant community establishes itself and the rooting depth increases (see Appendix A). In order to ensure that the system functions adequately at its eventual (minimum) hydraulic conductivity, a safety co-efficient of 2 should be used: i.e., **designs should be modelled using half the prescribed hydraulic conductivity**. If a system does not perform adequately with this hydraulic conductivity, then the area and/or ponding depth should be increased. It may also be desirable to report sensitivity to infiltration rate, rather than simply having expected rate. This is important when assessing compliance of constructed systems as systems should ideally meet best practice across a range of infiltration rates.

2 TESTING REQUIREMENTS

2.1 Determination of Hydraulic Conductivity

The hydraulic conductivity of potential filter media should be measured using the ASTM F1815-06 method. This test method uses a compaction method that best represents field conditions and so provides a more realistic assessment of hydraulic conductivity than other test methods.

Note: if a hydraulic conductivity lower than 100 mm/hr is prescribed, the level of compaction associated with this test method may be too severe and so underestimate the actual hydraulic conductivity of the filter media under field conditions. However, FAWB considers this to be an appropriately conservative test, and recommends its use even for low conductivity media.

2.2 Particle Size Distribution

Particle size distribution (PSD) is of secondary importance compared with hydraulic conductivity. A material whose PSD falls within the following recommended range does not preclude the need for hydraulic conductivity testing i.e., it does not guarantee that the material will have a suitable hydraulic conductivity. However, the following composition range (percentage w/w) provides a useful guide for selecting an appropriate material:

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Clay & Silt	<3%	(<0.05 mm)
Very Fine Sand	5-30%	(0.05-0.15 mm)
Fine Sand	10-30%	(0.15-0.25 mm)
Medium to Coarse Sand	40-60%	(0.25-1.0 mm)
Coarse Sand	7-10%	(1.0-2.0 mm)
Fine Gravel	<3%	(2.0-3.4 mm)

Clay and silt are important for water retention and sorption of dissolved pollutants, however they substantially reduce the hydraulic conductivity of the filter media. This size fraction also influences the structural stability of the material (through migration of particles to block small pores and/or slump). It is essential that the total clay and silt mix is **less than 3% (w/w)** to reduce the likelihood of structural collapse of such soils.

The filter media should be well-graded i.e., it should have all particle size ranges present from the 0.075 mm to the 4.75 mm sieve (as defined by AS1289.3.6.1 - 1995). There should be no gap in the particle size grading, and the composition should not be dominated by a small particle size range. This is important for preventing structural collapse due to particle migration.

2.3 Soil-Based Filter Media: Properties

The following specifications are based on results of extensive treatment performance testing conducted by FAWB as well as recommendations made by AS4419 – 2003 (Soils for Landscaping and Garden Use). Filter media must be tested for the following; media that do not meet these specifications should be rejected or amended:

i. Total Nitrogen (TN) Content – <1000 mg/kg.

ii. Orthophosphate (PO_4^{3-}) Content – <80 mg/kg. Soils with total phosphorus concentrations >100 mg/kg should be tested for potential leaching. Where plants with moderate phosphorus sensitivity are to be used, total phosphorus concentrations should be <20 mg/kg.

iii. Organic Matter Content – at least 3% (w/w). An organic content lower than 3% is likely to have too low a water holding capacity to support healthy plant growth. In order to comply with both this and the TN and PO_4^{3-} content requirements, a low nutrient organic matter will be required.

iv. pH – as specified for 'natural soils and soil blends' 5.5 – 7.5 (pH 1:5 in water).

v. Electrical Conductivity (EC) – as specified for 'natural soils and soil blends' <1.2 dS/m.

Optional testing:

vi. Dispersibility – this should be carried out where it is suspected that the soil may be susceptible to structural collapse. If in doubt, then this testing should be undertaken.

Potential filter media should generally be assessed by a horticulturalist to ensure that they are capable of supporting a healthy vegetation community. This assessment should take into

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consideration delivery of nutrients to the system by stormwater. Any component or soil found to contain high levels of salt (as determined by EC measurements), high levels of clay or silt particles (exceeding the particle size limits set above), or any other extremes which may be considered retardant to plant growth should be rejected.

3 ENGINEERED FILTER MEDIA

Where there is not a locally available soil-based material that complies with the properties outlined in Sections 2.1 - 2.3, it is possible to construct an appropriate filter medium. A washed, well-graded sand with an appropriate hydraulic conductivity should be used as the filter medium. Suitable materials include those used for the construction of turf profiles (e.g. golf greens); these materials are processed by washing to remove clay and silt fractions. In large quantities (>20 m^3), they can be obtained directly from sand suppliers, while smaller quantities can be purchased from local garden yards. The **top 100 mm of the filter medium** should then be ameliorated with appropriate organic matter, fertiliser and trace elements (Table 1). This amelioration is required to aid plant establishment and is designed to last four weeks; the rationale being that, beyond this point, the plants receive adequate nutrients via incoming stormwater.

Table 1. Recipe for ameliorating the top 100 mm of sand filter media

Constituent	Quantity (kg/100 m^2 filter area)
Granulated poultry manure fines	50
Superphosphate	2
Magnesium sulphate	3
Potassium sulphate	2
Trace Element Mix	1
Fertilizer NPK (16.4.14)	4
Lime	20

Laboratory testing has shown that biofilters that contain an engineered filter medium will achieve essentially the same hydraulic and treatment performance as those containing a soil-based filter medium (Bratieres *et al.*, 2009). However, it is recommended that a submerged zone be included in biofiltration systems that utilise such a free draining filter medium to provide a water source for vegetation between rainfall events.

4 TRANSITION LAYER

The transition layer prevents filter media from washing into the drainage layer. Transition layer material shall be a clean, well-graded sand material containing <2% fines. To avoid migration of the filter media into the transition layer, the particle size distribution of the sand should be assessed to ensure it meets 'bridging criteria', that is, the smallest 15% of the sand particles bridge with the largest 15% of the filter media particles (Water by Design, 2009; VicRoads, 2004):

D_{15} (transition layer) ≤ 5 x D_{85} (filter media)

where: D_{15} (transition layer) is the 15th percentile particle size in the transition layer material (i.e., 15% of the sand is smaller than D_{15} mm), and
D_{85} (filter media) is the 85th percentile particle size in the filter media.

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A dual-transition layer, where a fine sand overlays a medium-coarse sand, is also possible. While it is acknowledged that this can increase the complexity of the construction process, testing indicates that a dual-transition layer produces consistently lower levels of turbidity and concentrations of suspended solids in treated outflows than a single transition layer. Therefore, it is recommended that this design be specified for stormwater harvesting applications (to enable effective post-treatment disinfection) and where minimising the risk of washout during the establishment period is of particular importance.

The transition layer can be omitted from a biofiltration system provided the filter media and drainage layer meet the following criteria as defined by the Victorian Roads *Drainage of Subsurface Water from Roads - Technical Bulletin No 32* (VicRoads, 2004):

D_{15} (drainage layer) ≤ 5 x D_{85} (filter media)

D_{15} (drainage layer) = 5 to 20 x D_{15} (filter media)

D_{50} (drainage layer < 25 x D_{50} (filter media)

D_{60} (drainage layer) < 20 x D_{10} (drainage layer)

These comparisons are best made by plotting the particle size distributions for the filter media and gravel on the same soil grading graphs and extracting the relevant diameters (Water by Design, 2009).

5 DRAINAGE LAYER

The drainage layer collects treated water at the bottom of the system and converys it to the underdrain pipes. Drainage layer material is to be clean, fine gravel, such as a 2 – 5 mm washed screenings. Bridging criteria should be applied to avoid migration of the transition layer into the drainage layer (Water by Design, 2009; VicRoads, 2004):

D_{15} (drainage layer) ≤ 5 x D_{85} (transition layer)

where: D_{15} (drainage layer) is the 15th percentile particle size in the drainage layer material (i.e., 15% of the gravel is smaller than D_{15} mm), and
D_{85} (transition layer) is the 85th percentile particle size in the transition layer material.

Note: The perforations in the underdrain pipes should be small enough that the drainage layer cannot fall into the pipes. A useful guide is to check to that the D_{85} (drainage layer) is greater than the pipe perforation diameter.

Geotextile fabrics are **not recommended** for use in biofiltration systems due to the risk of clogging. An open-weave shade cloth can be placed between the transition layer and the drainage layer to help reduce the downward migration of smaller particles if required, however this should only be adopted where there is insufficient depth for transition and drainage layers.

6 INSTALLATION

It is recommended that filter media be lightly compacted during installation to prevent migration of fine particles. In small systems, a single pass with a vibrating plate should be used to compact the filter media, while in large systems, a single pass with roller machinery (e.g. a drum lawn roller) should be performed. Under no circumstance should heavy compaction or multiple-passes be made. Filter media should be installed in two lifts unless the depth is less than 500 mm.

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7 FIELD TESTING

It is recommended that field testing of hydraulic conductivity be carried out at least twice: 1. one month following commencement of operation, and 2. in the second year of operation to assess the impact of vegetation on hydraulic conductivity.

The hydraulic conductivity of the filter media should be checked at a minimum of three points within the system. The single ring, constant head infiltration test method (shallow test), as described by Le Coustumer *et al.* (2007), should be used. Given the inherent variability in hydraulic conductivity testing and the heterogeneity of the filter media, the laboratory and field results are considered comparable if they are within 50% of each other. However, even if they differ by more than 50%, the system will still function if both the field and laboratory results are within the relevant recommended range of hydraulic conductivities.

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APPENDIX A

Figure A.1 illustrates the change in hydraulic conductivity during the establishment phase of a Melbourne biofiltration system containing a sandy loam filter media. The hydraulic conductivity initially declines as the filter media is compacted under hydraulic loading, but recovers back to the design value (as indicated by the dashed horizontal line) as plant growth and increased rooting depth counters the effects of compaction and clogging.

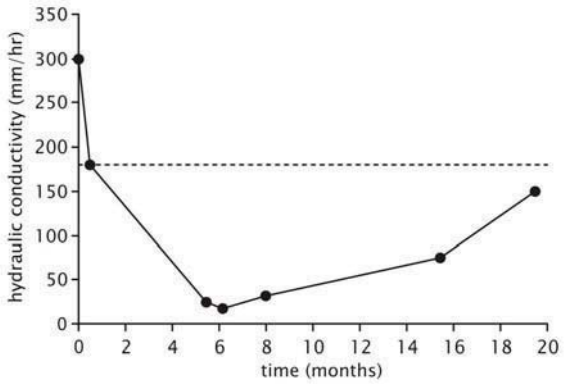

Figure A.1 Evolution of hydraulic conductivity during the first 20 months of a biofiltration system (after Hatt *et al.*, 2009)

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ROL1 – RIVERSIDE, JIMBOOMBA

Appendix H Concept Drawings

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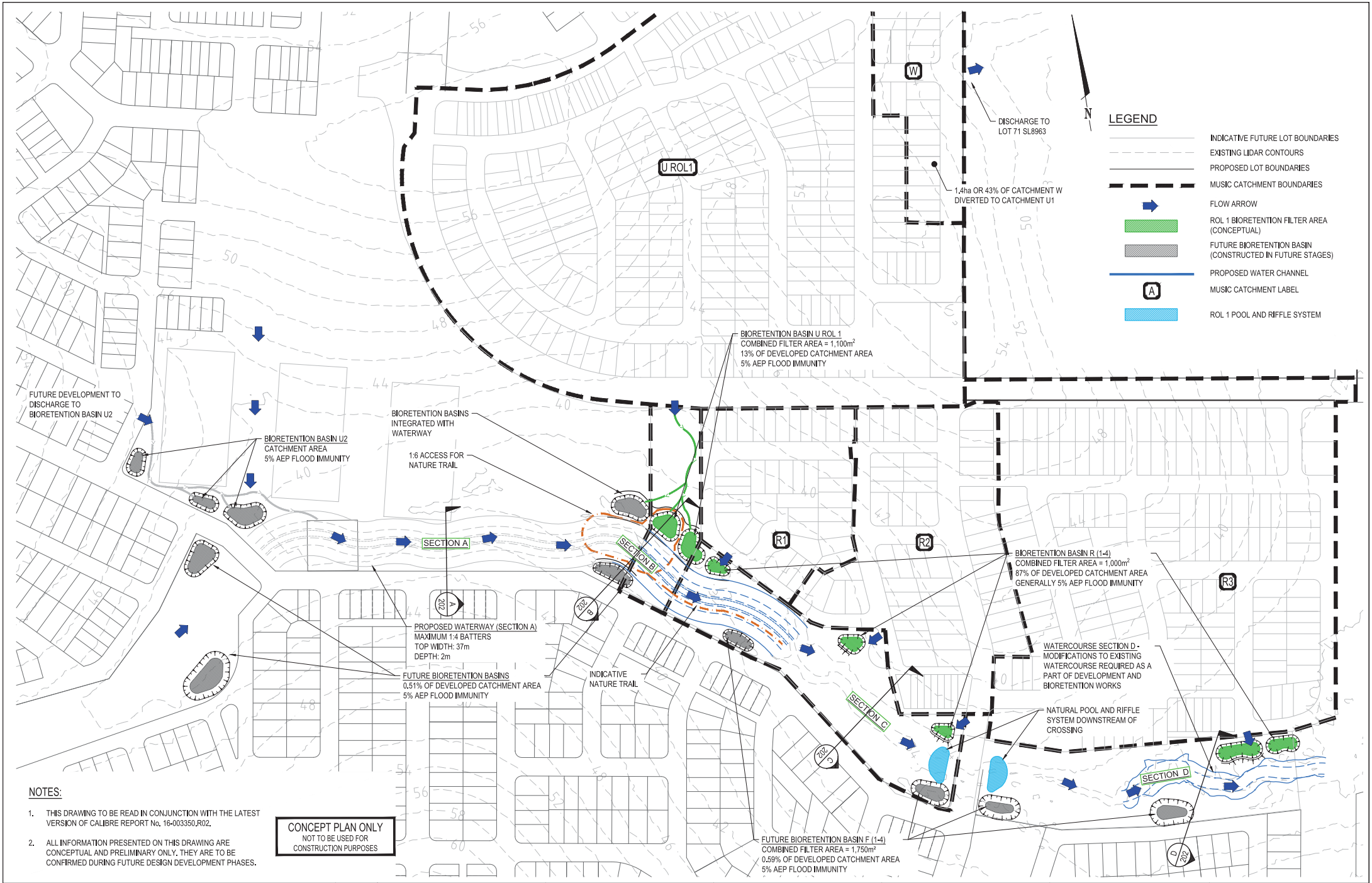

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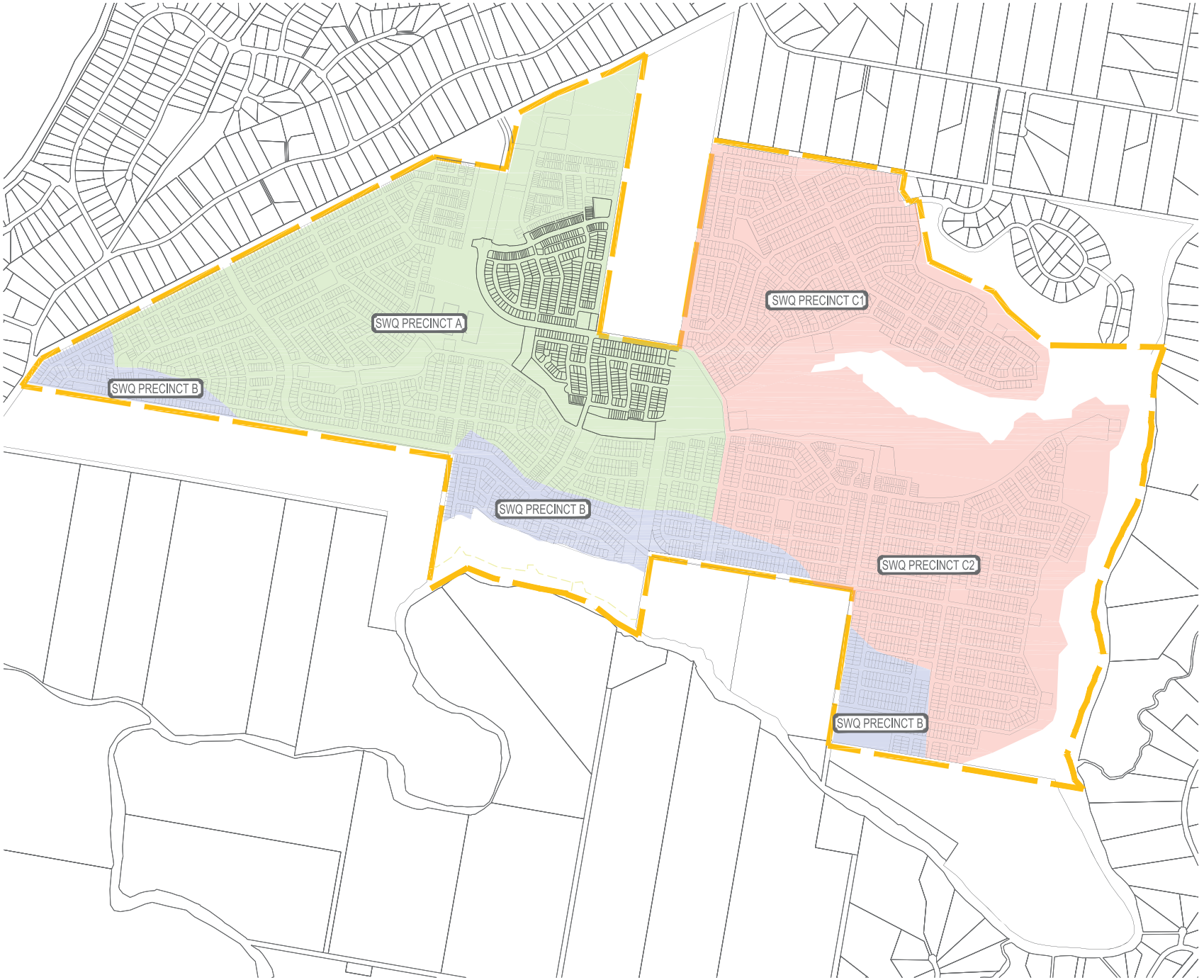

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- FUTURE LOT BOUNDARY (INDICATIVE ONLY)
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- STORMWATER QUALITY PRECINCT B
- STORMWATER QUALITY PRECINCT C
- SWQ PRECINCT A — STORMWATER QUALITY PRECINCT LABEL

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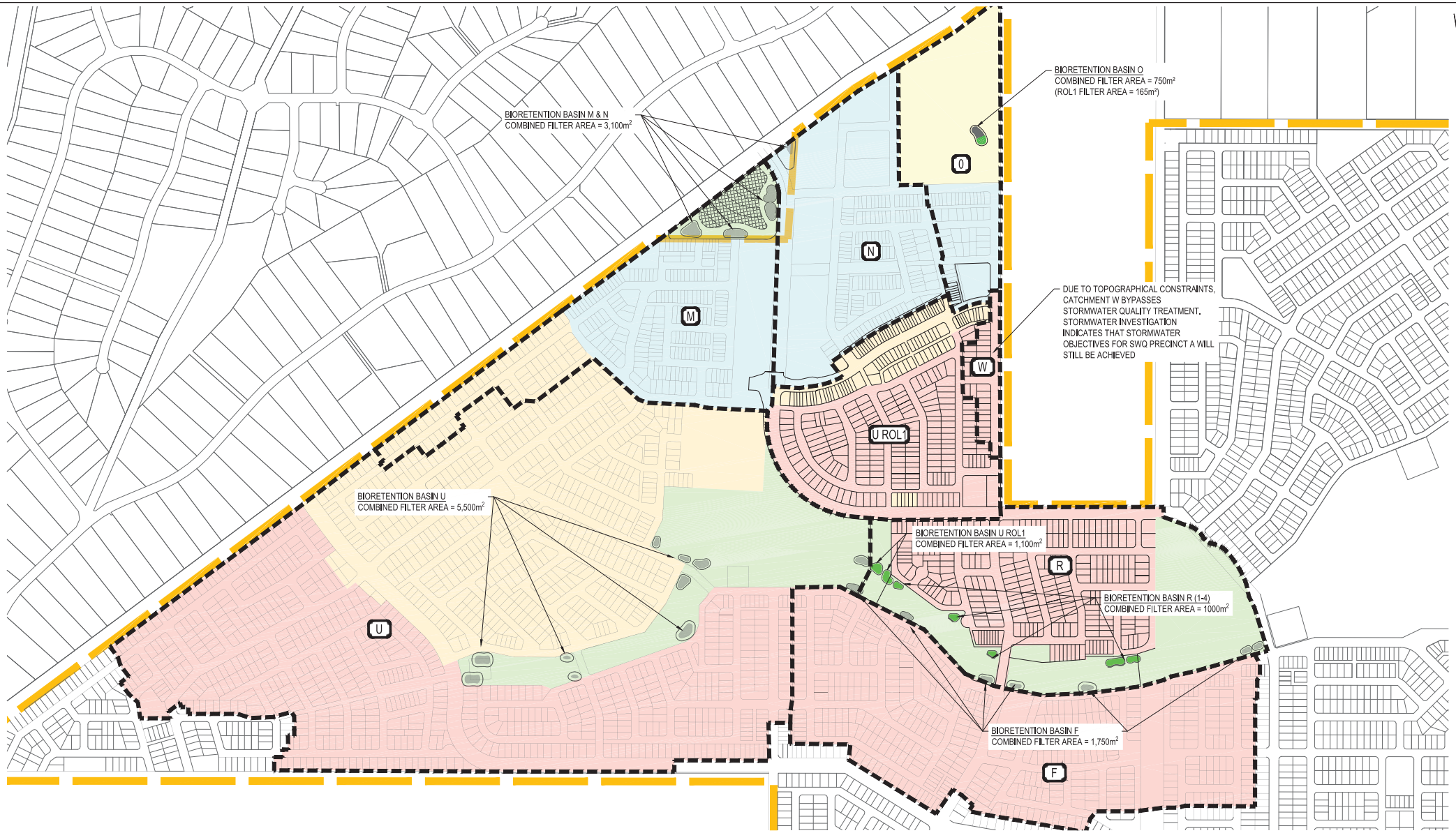

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- FUTURE BIORETENTION BASIN (CONSTRUCTED IN FUTURE STAGES)
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- HIGH DENSITY AREA
- MEDIUM DENSITY AREA
- SCHOOL AREA
- PARK AREA
- COMMERCIAL AREA

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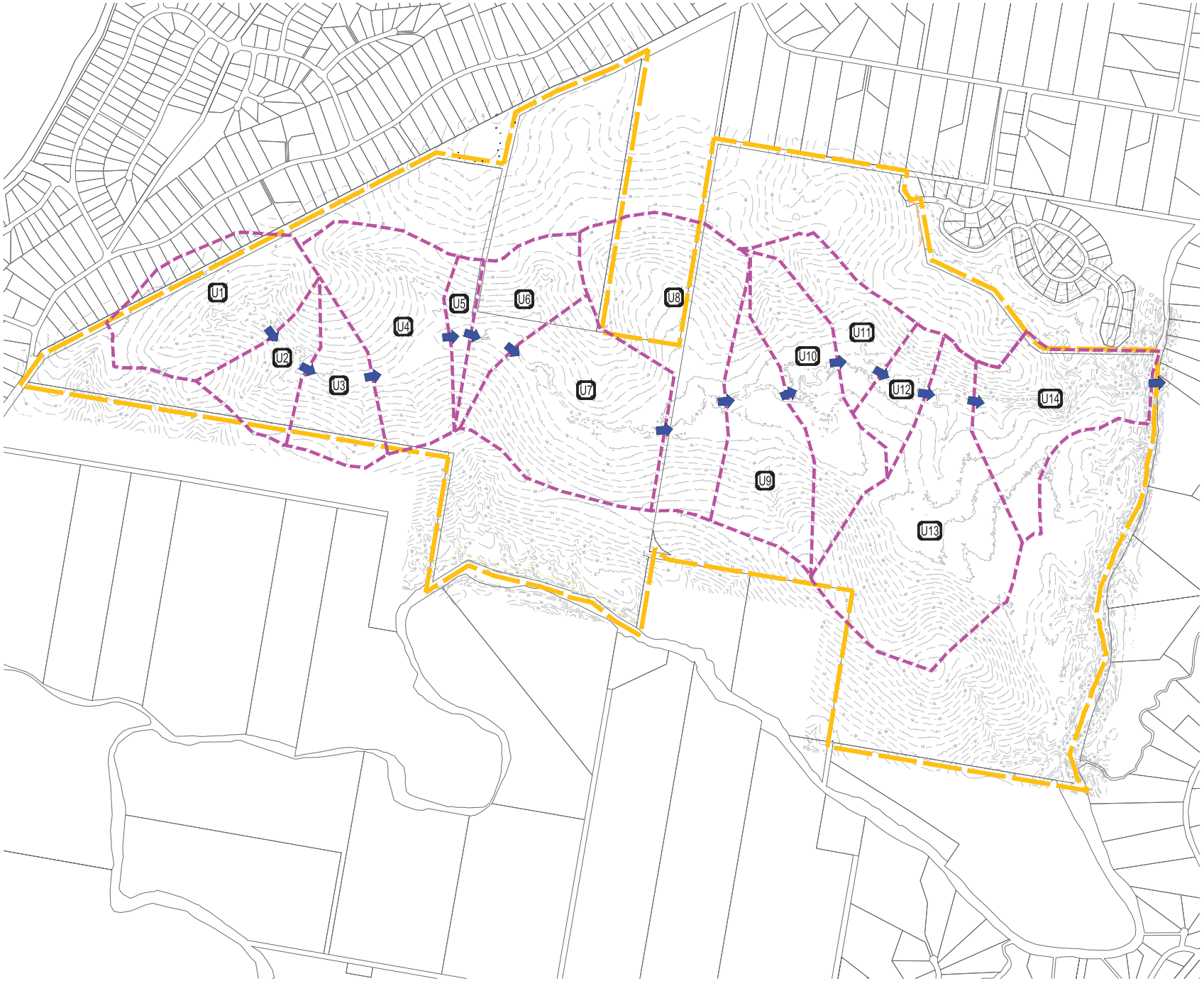

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U3	16.25
U4	33.47
U5	4.92
U6	17.03
U7	43.54
U8	45.87
U9	25.82
U10	26.12
U11	15.73
U12	9.39
U13	56.54
U14	30.00

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- EXISTING CONTOURS (2m)
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- FLOW DIRECTION
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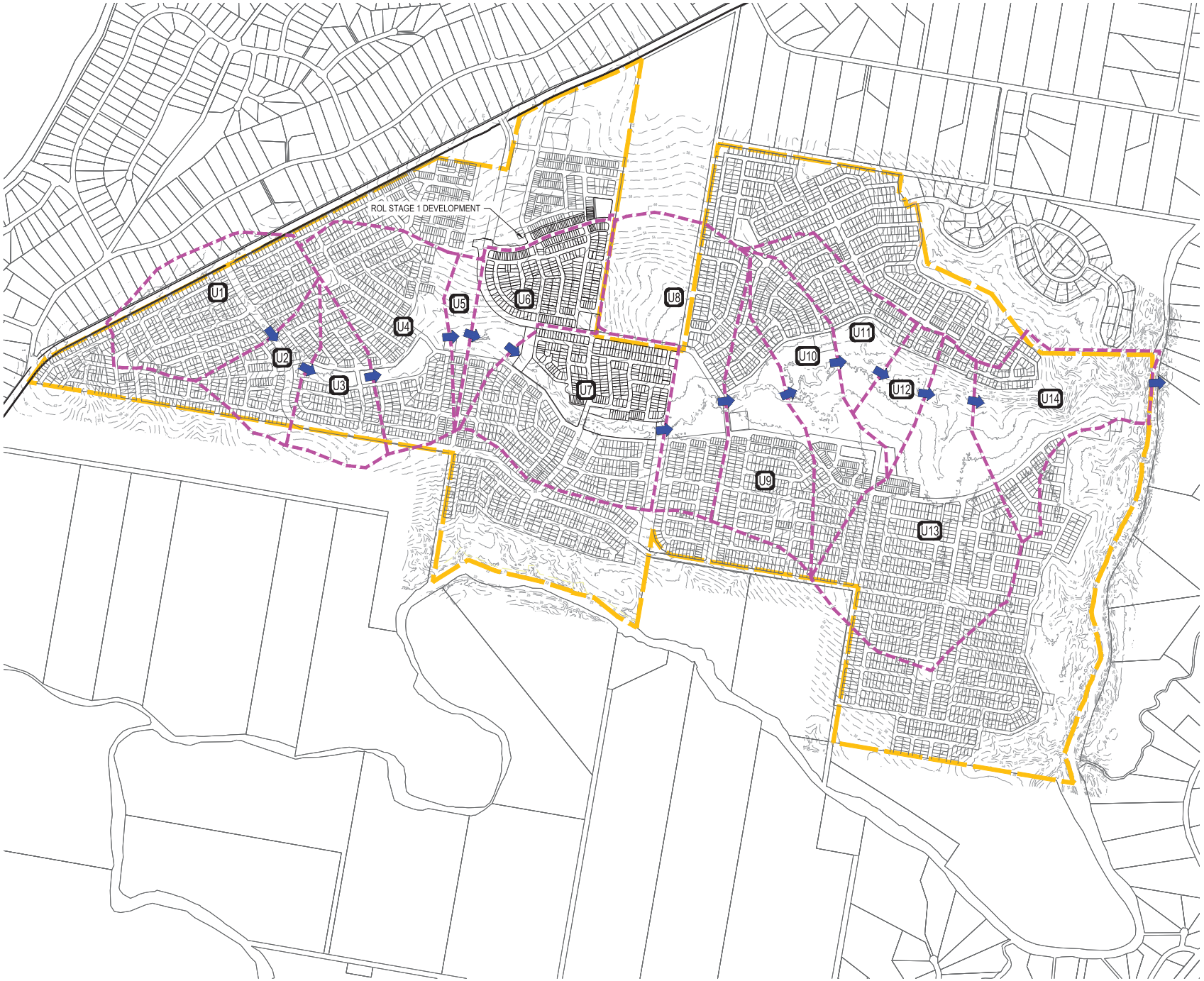

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- EXISTING CADASTRE
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- FUTURE LOT BOUNDARY (INDICATIVE ONLY)
- EXISTING CONTOURS (2m)
- XP-RAFTS CATCHMENT BOUNDARY
- FLOW DIRECTION
- A — DEVELOPED CATCHMENT LABEL

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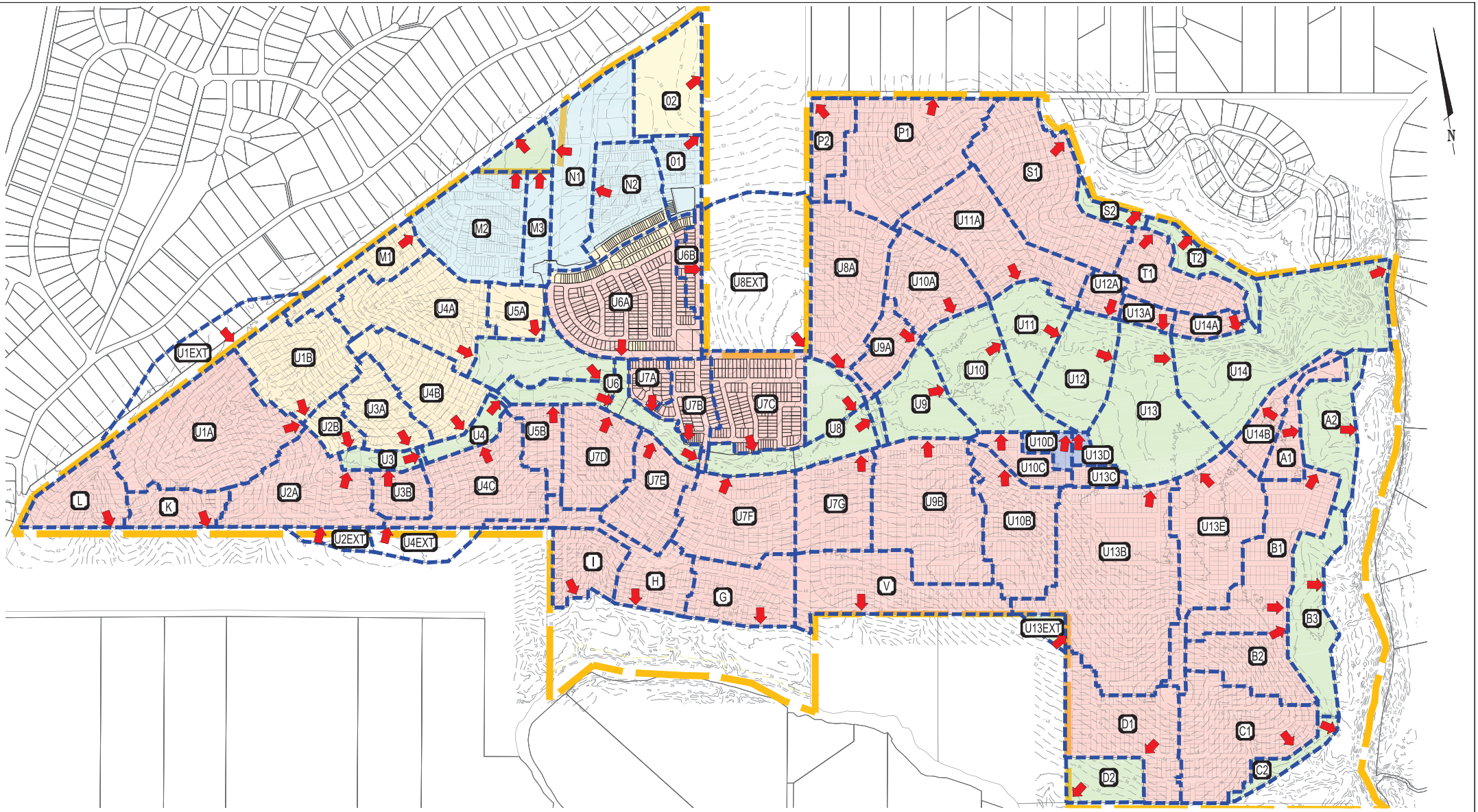
PROJECT No.	DRAWING No.	REVISION
16-003350	SK207	C



LEGEND

- OVERALL MASTER PLAN AREA
- XP-RAFTS CATCHMENT BOUNDARIES
- EXISTING LIDAR CONTOURS
- EXISTING CADASTRE
- ROL STAGE 1 LOT BOUNDARY
- FUTURE LOT BOUNDARY (INDICATIVE ONLY)
- HIGH DENSITY AREA
- MEDIUM DENSITY AREA
- SCHOOL AREA
- COMMUNITY SERVICES
- PARK AREA
- COMMERCIAL AREA
- FLOW DIRECTION
- A — XP-RAFTS CATCHMENT LABEL

NOTES:

1. THIS DRAWING TO BE READ IN CONJUNCTION WITH THE LATEST VERSION OF CALIBRE REPORT No. 16-003350.R02.
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REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	15.06.17	ORIGINAL ISSUE	RH	CM
B	06.11.17	DENSITY AMENDMENTS	RH	GB
C	07.12.17	ROL1 UPDATE	RH	GB
D	28.02.19	RFI RESPONSE	RH	MP
E				
F				
G				
H				

DRAWN

DESIGN

STATUS: NOT FOR CONSTRUCTION

APPROVED

SCALE: NTS

CLIENT: Riverside CELESTINO

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PROJECT: RIVERSIDE CELESTINO JIMBOOMBA

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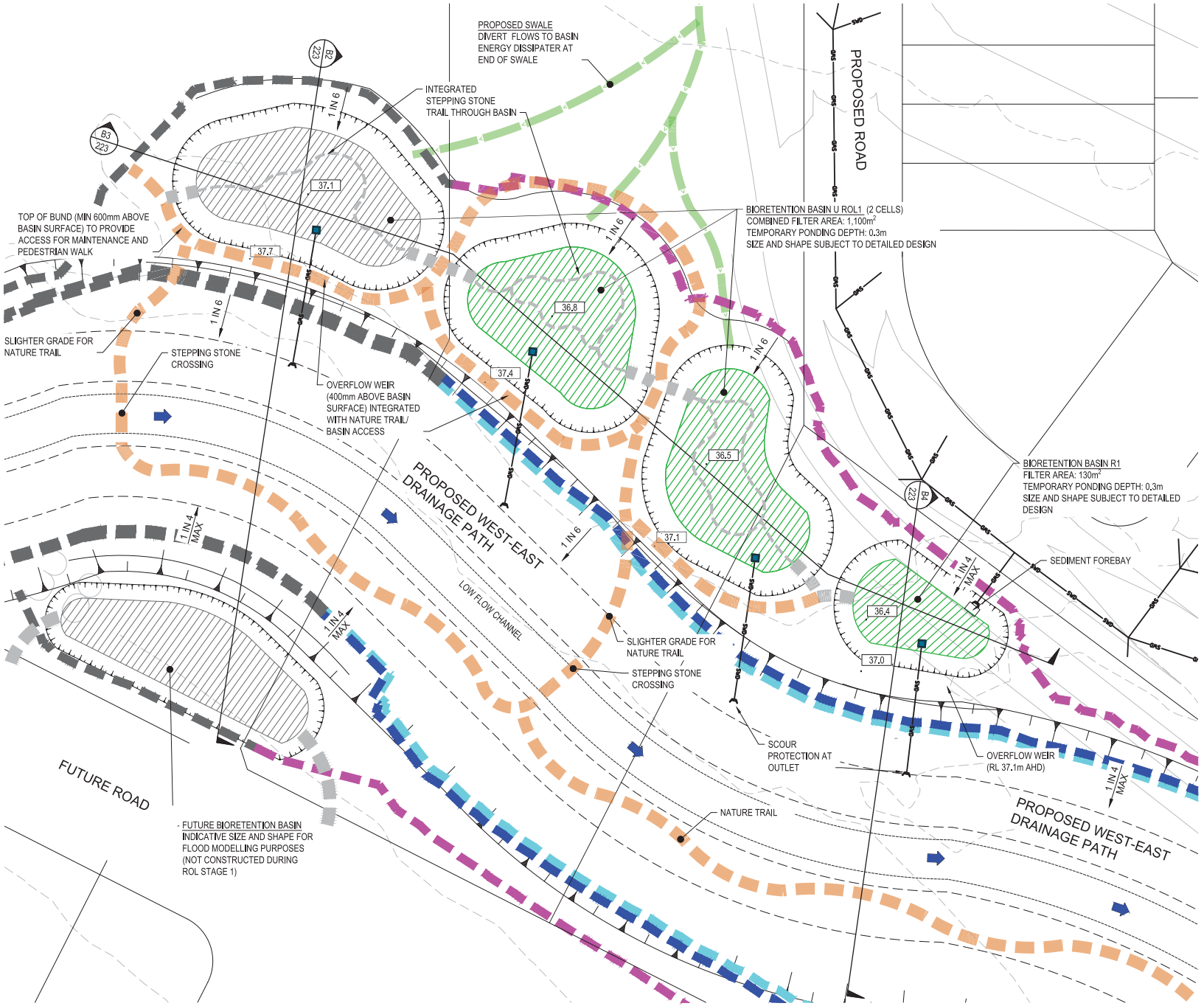
DRAWING TITLE: OVERALL MASTERPLAN XP-RAFTS CATCHMENT PLAN

PROJECT No.	DRAWING No.	REVISION
16-003350	SK208	D

ROL1 – RIVERSIDE, JIMBOOMBA

Appendix I Concept Basin Plans

CELESTINO PTY LTD



LEGEND

- PROPOSED LOT BOUNDARIES
- EXISTING LIDAR CONTOURS
- DESIGN CONTOURS (CONCEPT ONLY)
- PROPOSED STEPPING STONES WITHIN BASIN
- 1% AEP ULTIMATE HIGH MANNING's FLOOD LEVEL (n=0.15)
- 1% AEP ULTIMATE FLOOD LEVELS
- 5% AEP ULTIMATE FLOOD LEVELS
- 1:6 ACCESS TO BASIN (MAINTENANCE)
- COMBINED NATURE TRAIL AND ACCESS TO BASIN
- PROPOSED STORMWATER DRAINAGE
- PROPOSED SWALE
- 39.1 INDICATIVE DESIGN LEVELS
- FLOW ARROW
- BIORETENTION BASIN FILTER AREA
- FUTURE BIORETENTION BASIN (CONSTRUCTED IN FUTURE STAGES)

CONCEPT PLAN ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

NOTES:

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3. PROPOSED BIORETENTION BASINS ARE DESIGNED WITH AN OVERFLOW WEIR 400mm ABOVE THE BASIN SURFACE, A MINIMUM TOP OF EMBANKMENT LEVEL 600mm ABOVE THE BASIN SURFACE AND A TEMPORARY PONDING DEPTH OF 300mm.

REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	02.06.17	ORIGINAL ISSUE	RH	CM
B	08.12.17	ROL1 UPDATE	RH	GB
C				
D				
E				
F				
G				
H				

DRAWN
DESIGN

STATUS: **NOT FOR CONSTRUCTION**
APPROVED

SCALE: 1:250 5 0 5 10 A1 / 1:500 A3

CLIENT: Riverside CELESTINO

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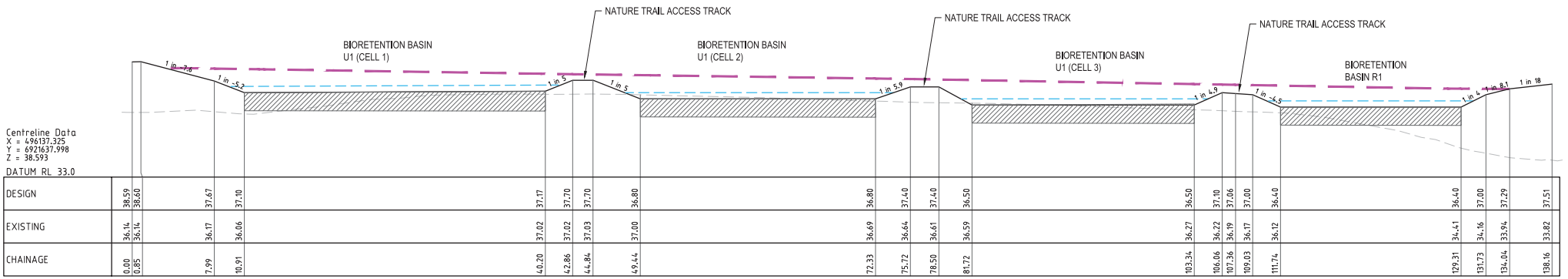
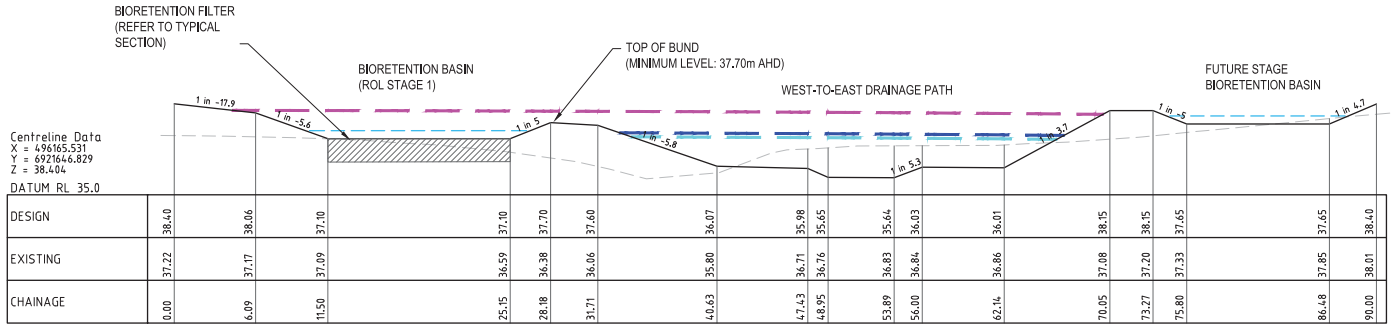
DRAWING TITLE: **BIORETENTION BASIN R1 & U2 CONCEPT DESIGN PLAN**

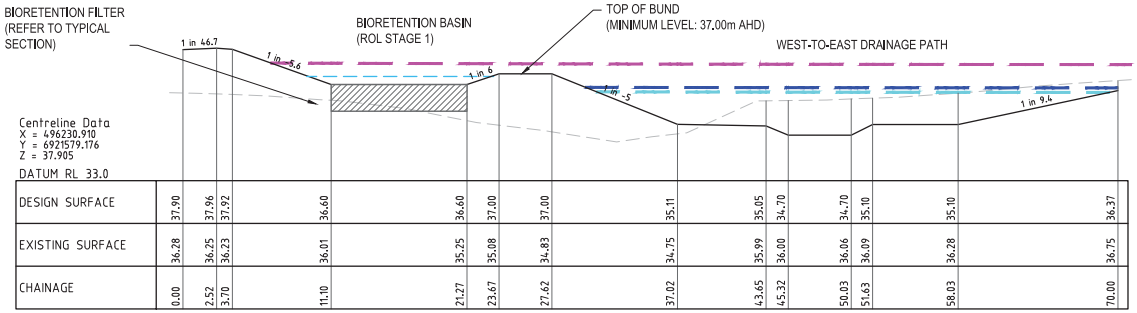
PROJECT No.	DRAWING No.	REVISION
16-003350	SK222	B



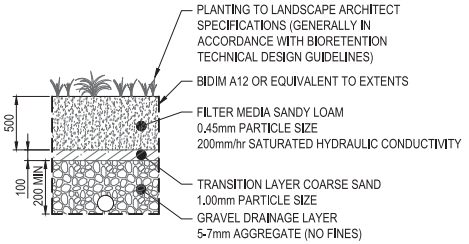
SECTION B3
SCALE (A1): 222
SCALE (A3):



SECTION B2
SCALE (A1): 222
SCALE (A3):



SECTION B4
SCALE (A1): 222
SCALE (A3):



TYPICAL BIORETENTION SECTION

SCALE 1:20 (A1)
SCALE 1:40 (A3)

LEGEND

- PROPOSED SURFACE
- EXISTING SURFACE
- 1% AEP ULTIMATE HIGH MANNING's FLOOD LEVEL (n=0.15)
- 1% AEP ULTIMATE FLOOD LEVELS
- 5% AEP ULTIMATE FLOOD LEVELS
- BASIN TEMPORARY PONDING DEPTH (300mm ABOVE FILTER SURFACE)
- BIORETENTION FILTER AREAS REFER TO TYPICAL SECTION

CONCEPT PLAN ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

NOTES:

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REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	20.06.17	ORIGINAL ISSUE	RH	CM
B	08.12.17	ROL1 UPDATE	RH	GB
C				
D				
E				
F				
G				
H				

DRAWN
DESIGN
STATUS: **NOT FOR CONSTRUCTION**
APPROVED

SCALE
1:100 1 0 1 2 3 4 5 A1
1:200 A3
VERTICAL SCALE
1:500 10 5 0 10 20 A1
1:1000 A3
HORIZONTAL SCALE

CLIENT: Riverside CELESTINO

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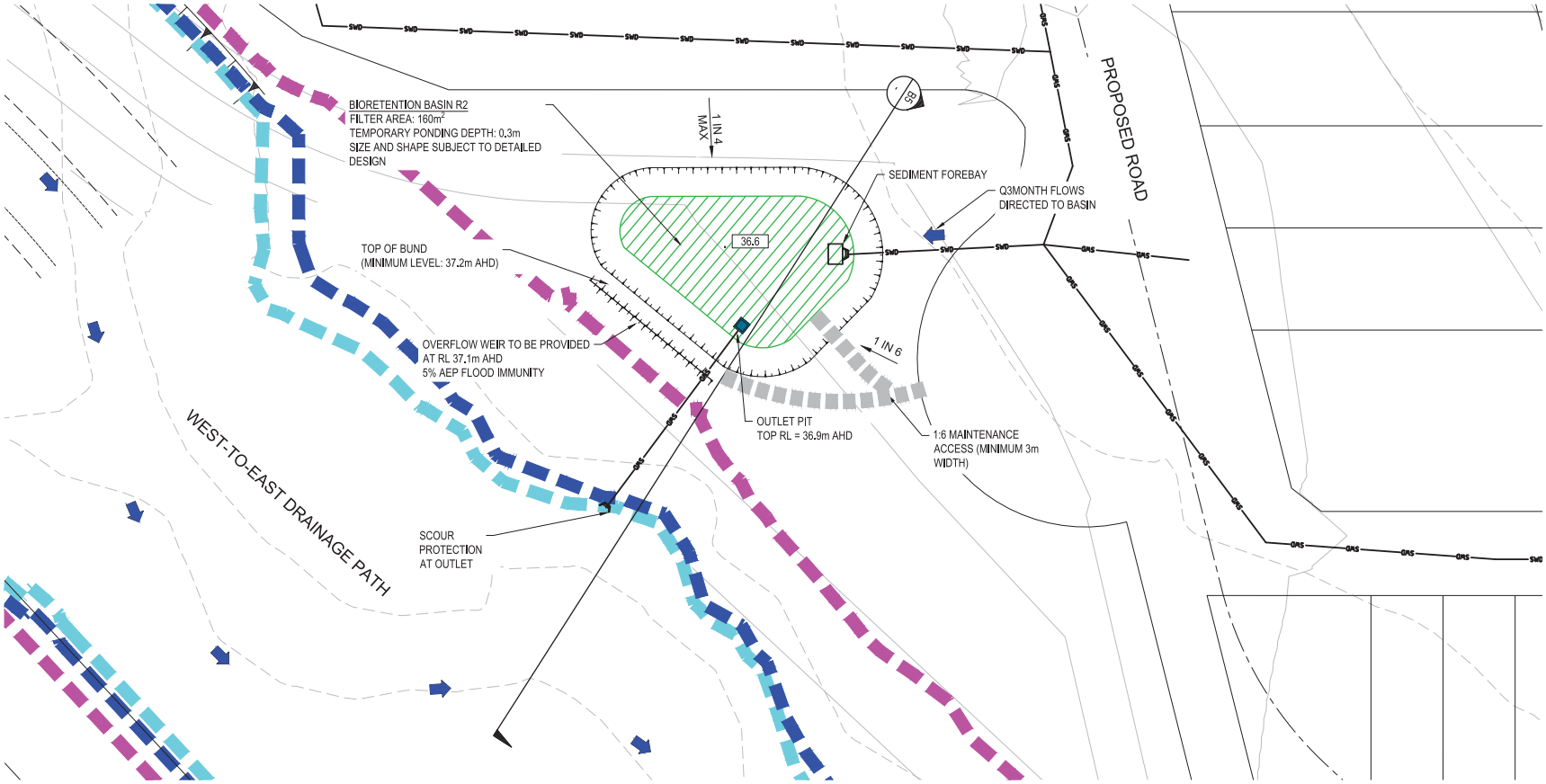
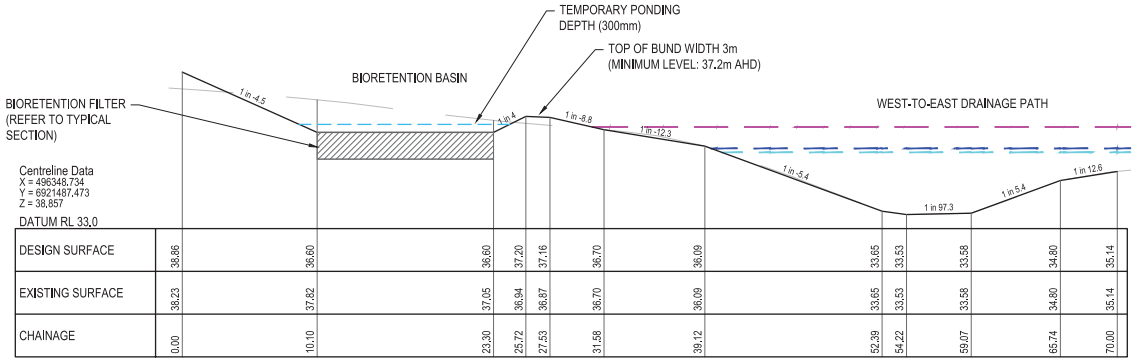
DRAWING TITLE: **BIORETENTION BASIN R1 & U2 CONCEPT DESIGN SECTIONS PLAN**

PROJECT No.	DRAWING No.	REVISION
16-003350	SK223	B



LEGEND

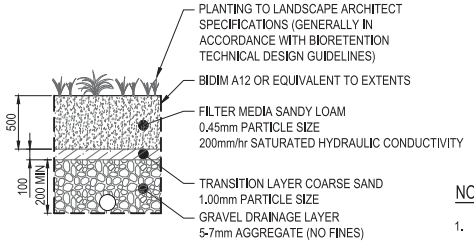
- PROPOSED LOT BOUNDARIES
- EXISTING LIDAR CONTOURS
- DESIGN CONTOURS (CONCEPT ONLY)
- 1% AEP ULTIMATE HIGH MANNING'S FLOOD LEVEL (n=0.15)
- 1% AEP ULTIMATE FLOOD LEVELS
- 5% AEP ULTIMATE FLOOD LEVELS
- MAINTENANCE ACCESS
- PROPOSED STORMWATER DRAINAGE
- PROPOSED SWALE
- 39.1 INDICATIVE DESIGN LEVELS
- FLOW ARROW
- BIORETENTION BASIN FILTER AREA
- FUTURE BIORETENTION BASIN (CONSTRUCTED IN FUTURE STAGES)



DESIGN SURFACE	38.86	36.60	36.60	37.20	37.16	36.70	36.09	33.65	33.53	33.58	34.80	35.14		
EXISTING SURFACE	38.23	37.82	37.05	36.94	36.87	36.70	36.09	33.65	33.53	33.58	34.80	35.14		
CHAINAGE	0.00	10.10	23.30	25.72	27.53	31.58	39.12	52.39	54.22	59.07	65.74	70.00		

SECTION B5/224
SCALE (A1): 1:200
SCALE (A3): 1:400

1:100 1 0 1 2 3 4 5 A1
1:200 A3
VERTICAL SCALE (SECTION ONLY)



TYPICAL BIORETENTION SECTION
SCALE 1:20 (A1)
SCALE 1:40 (A3)

CONCEPT PLAN ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

NOTES:

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REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	02.06.17	ORIGINAL ISSUE	RH	CM
B	08.12.17	ROL1 UPDATE	RH	GB
C				
D				
E				
F				
G				
H				

DRAWN
DESIGN
STATUS: NOT FOR CONSTRUCTION
APPROVED
SCALE: 1:200 2 0 2 4 6 8 10 A1; 1:400 A3
CLIENT: Riverside CELESTINO

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PROJECT: RIVERSIDE CELESTINO JIMBOOMBA

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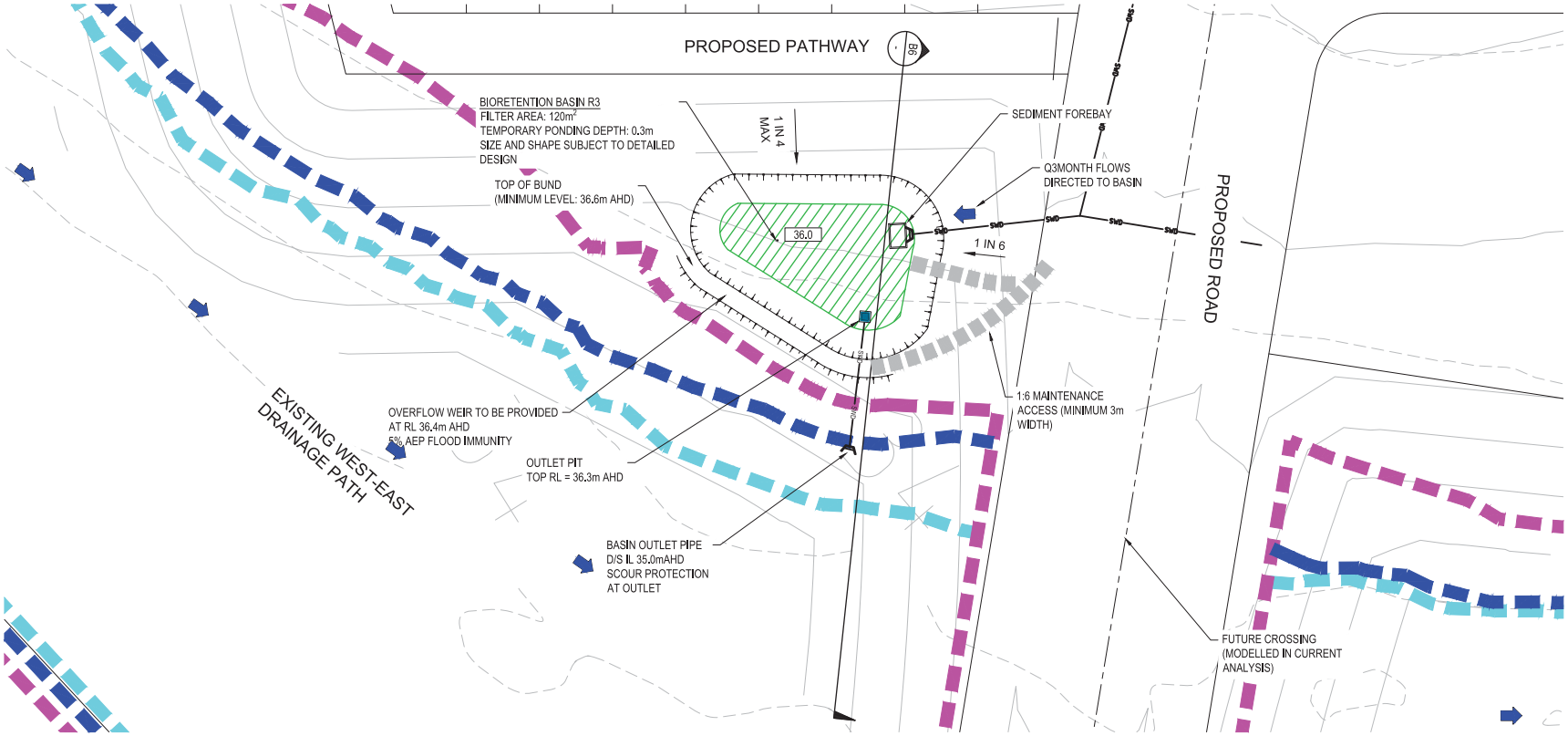
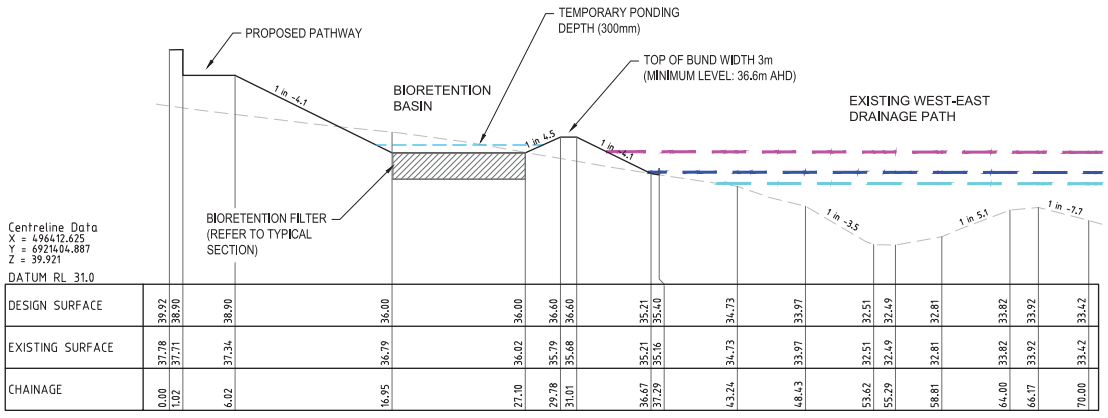
DRAWING TITLE: BIORETENTION BASIN R2 CONCEPT DESIGN PLAN

PROJECT No.	DRAWING No.	REVISION
16-003350	SK224	B

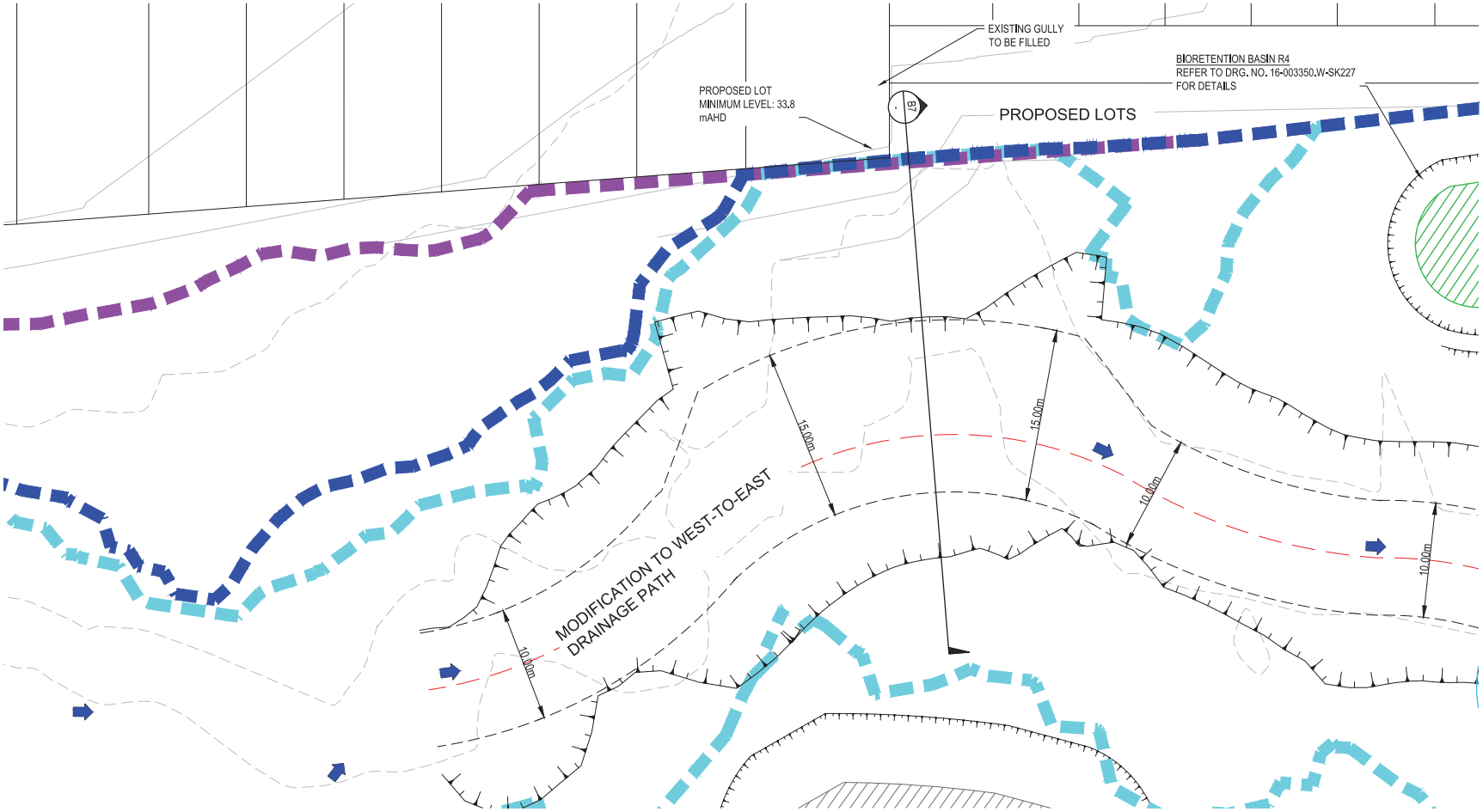


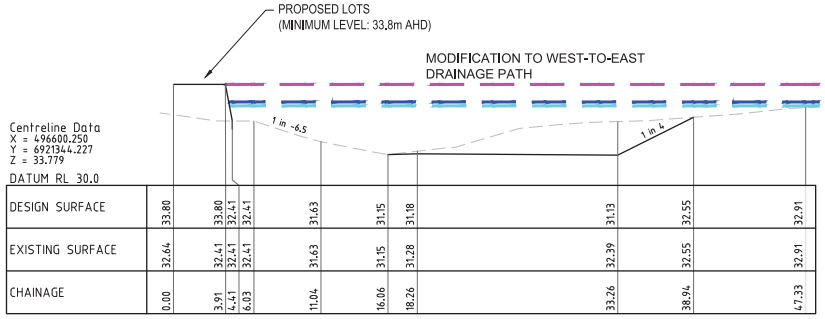
LEGEND

- PROPOSED LOT BOUNDARIES
- EXISTING LIDAR CONTOURS
- DESIGN CONTOURS (CONCEPT ONLY)
- 1% AEP ULTIMATE HIGH MANNING's FLOOD LEVEL (n=0.15)
- 1% AEP ULTIMATE FLOOD LEVELS
- 5% AEP ULTIMATE FLOOD LEVELS
- MAINTENANCE ACCESS
- PROPOSED STORMWATER DRAINAGE
- 39.1 INDICATIVE DESIGN LEVELS
- FLOW ARROW
- BIORETENTION BASIN FILTER AREA



| | | |





Centreline Data
X = 496600.259
Y = 6921344.227
Z = 33.779

DATUM RL 30.0

DESIGN SURFACE	33.80	33.80	32.41	32.41	31.63	31.15	31.18	31.13	32.55	32.91
EXISTING SURFACE	32.64	32.41	32.41	32.41	31.63	31.15	31.28	32.39	32.55	32.91
CHAINAGE	0.00	3.91	4.41	6.03	11.04	16.06	18.26	33.26	38.94	47.33

SECTION B7 / 224
SCALE (A1): 1:200
SCALE (A3): 1:400

1:100 1 0 1 2 3 4 5 A1
1:200 A3
VERTICAL SCALE (SECTION ONLY)

LEGEND

- PROPOSED LOT BOUNDARIES
- EXISTING LIDAR CONTOURS
- DESIGN CONTOURS (CONCEPT ONLY)
- 1% AEP ULTIMATE HIGH MANNING's FLOOD LEVEL (n=0.15)
- 1% AEP ULTIMATE FLOOD LEVELS
- 5% AEP ULTIMATE FLOOD LEVELS
- FLOW ARROW
- BIORETENTION BASIN FILTER AREA
- FUTURE BIORETENTION BASIN (CONSTRUCTED IN FUTURE STAGES)

CONCEPT PLAN ONLY
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REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	20.06.17	ORIGINAL ISSUE	RH	CM
B	08.12.17	ROL1 UPDATE	RH	GB
C				
D				
E				
F				
G				
H				

DRAWN
DESIGN
STATUS: NOT FOR CONSTRUCTION
APPROVED
SCALE: 1:200 2 0 2 4 6 8 10 A1 / 1:400 A3

CLIENT: Riverside CELESTINO

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PROJECT
RIVERSIDE CELESTINO JIMBOOMBA

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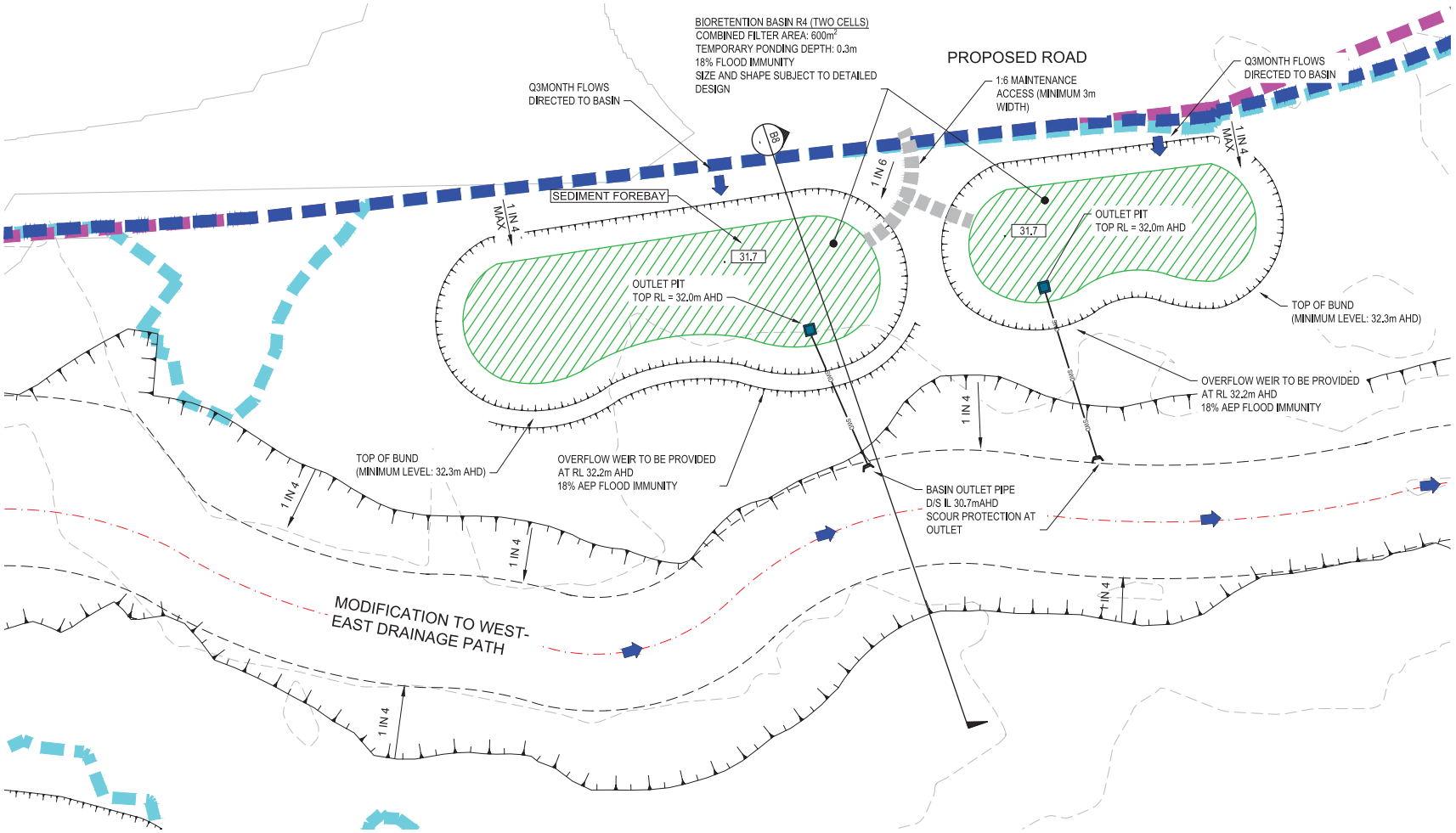
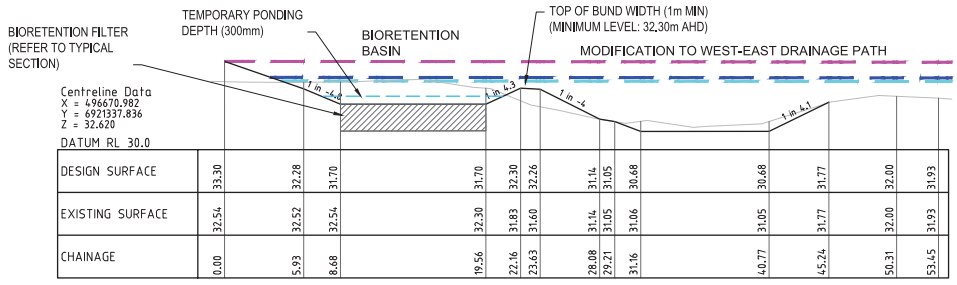
DRAWING TITLE
CONCEPT WEST-EAST DRAINAGE PATH PLAN (SECTION D)

PROJECT No.	DRAWING No.	REVISION
16-003350	SK226	B



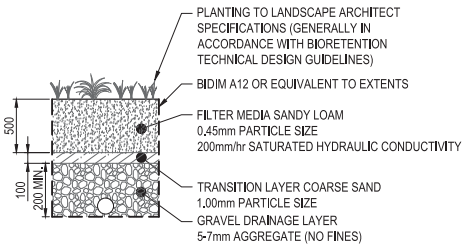
LEGEND

- PROPOSED LOT BOUNDARIES
- EXISTING LIDAR CONTOURS
- DESIGN CONTOURS (CONCEPT ONLY)
- 1% AEP ULTIMATE HIGH MANNING's FLOOD LEVEL (n=0.15)
- 1% AEP ULTIMATE FLOOD LEVELS
- 5% AEP ULTIMATE FLOOD LEVELS
- MAINTENANCE ACCESS TRACK
- PROPOSED STORMWATER DRAINAGE (SWD)
- 39.1 INDICATIVE DESIGN LEVELS
- FLOW ARROW
- BIORETENTION BASIN FILTER AREA



DESIGN SURFACE	33.30		32.28	31.70		31.70	32.30	32.26	31.14	31.05	30.68		30.68	31.77		32.00	31.93							
EXISTING SURFACE	32.54		32.52	32.54		32.30	31.83	31.60	31.14	31.05	31.06		31.05	31.77		32.00	31.93							
CHAINAGE	0.00		5.93	8.68		19.56	22.16	23.63	28.08	29.21	31.16		40.77	45.24		50.31	53.45							

SECTION B8/224
SCALE (A1): 1:200
SCALE (A3): 1:400
VERTICAL SCALE (SECTION ONLY) 1:100 / 1:200 — 1 0 1 2 3 4 5 — A1 / A3



TYPICAL BIORETENTION SECTION
SCALE 1:20 (A1)
SCALE 1:40 (A3)

CONCEPT PLAN ONLY
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NOTES:

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REVISION	DATE	ISSUE DETAILS	DRAWN	DESIGN
A	20.06.17	ORIGINAL ISSUE	RH	CM
B	08.12.17	ROL1 UPDATE	RH	GB
C				
D				
E				
F				
G				
H				

DRAWN
DESIGN
STATUS: **NOT FOR CONSTRUCTION**
APPROVED
SCALE: 1:200 / 1:400 — 2 0 2 4 6 8 10 — A1 / A3
CLIENT: Riverside CELESTINO

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PROJECT: **RIVERSIDE CELESTINO JIMBOOMBA**

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DRAWING TITLE: **BIORETENTION BASIN R4 CONCEPT DESIGN PLAN**

PROJECT No.	DRAWING No.	REVISION
16-003350	SK227	B